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THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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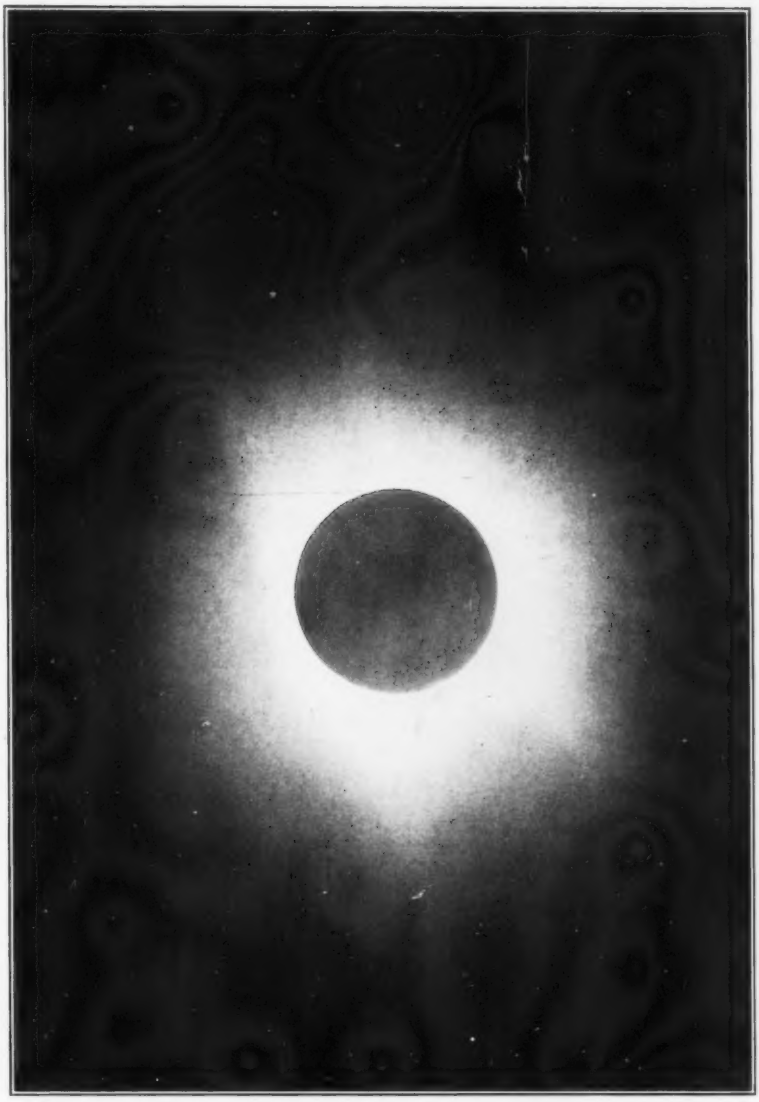
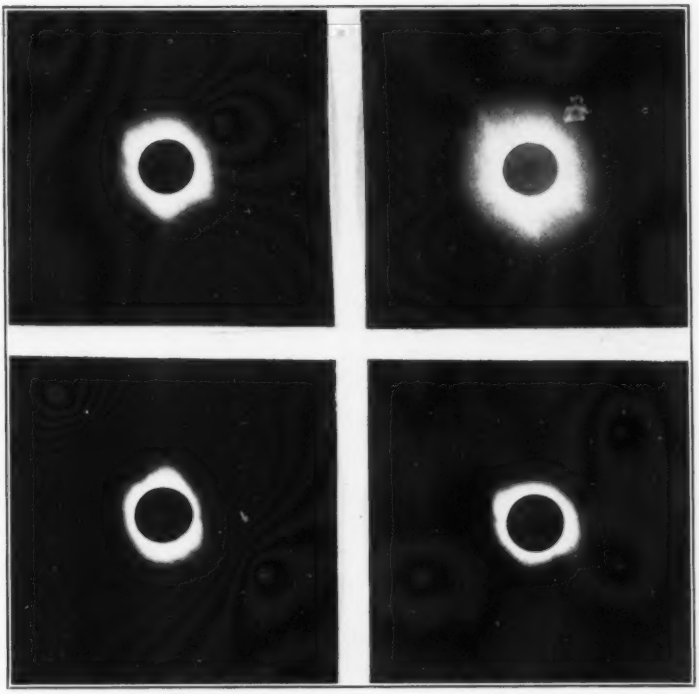
PLATE I.

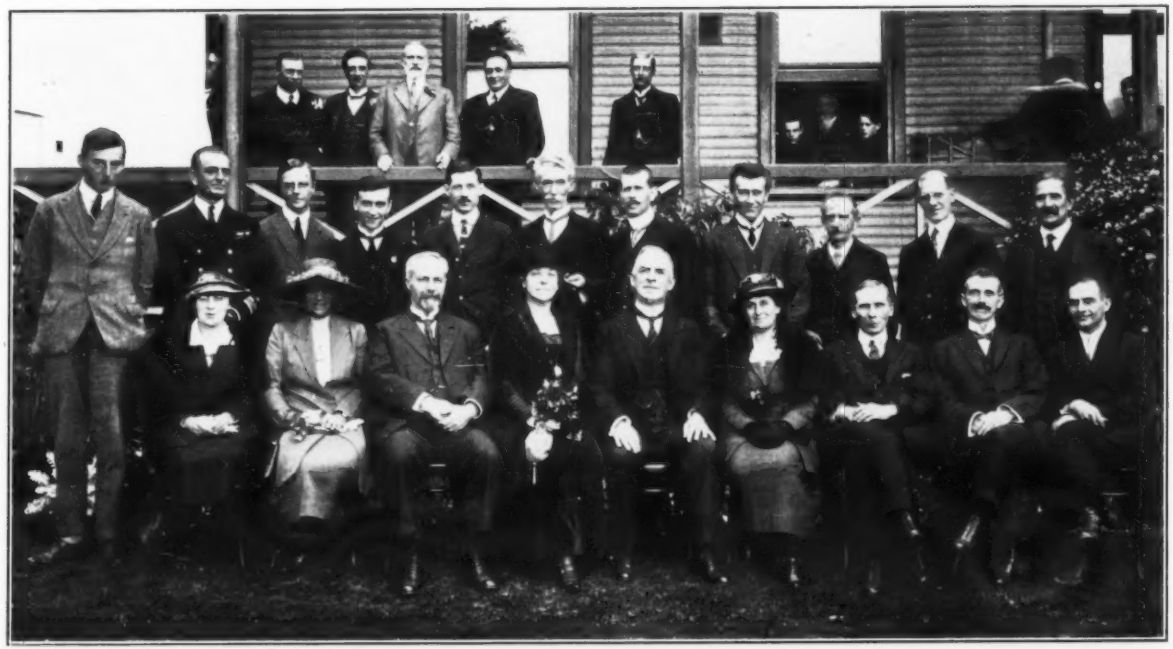


Solar Corona, September 21, 1923. Taken at Wallal, W.A., with 11-foot Einstein Camera. Exposure 45 sec.

PLATE II.



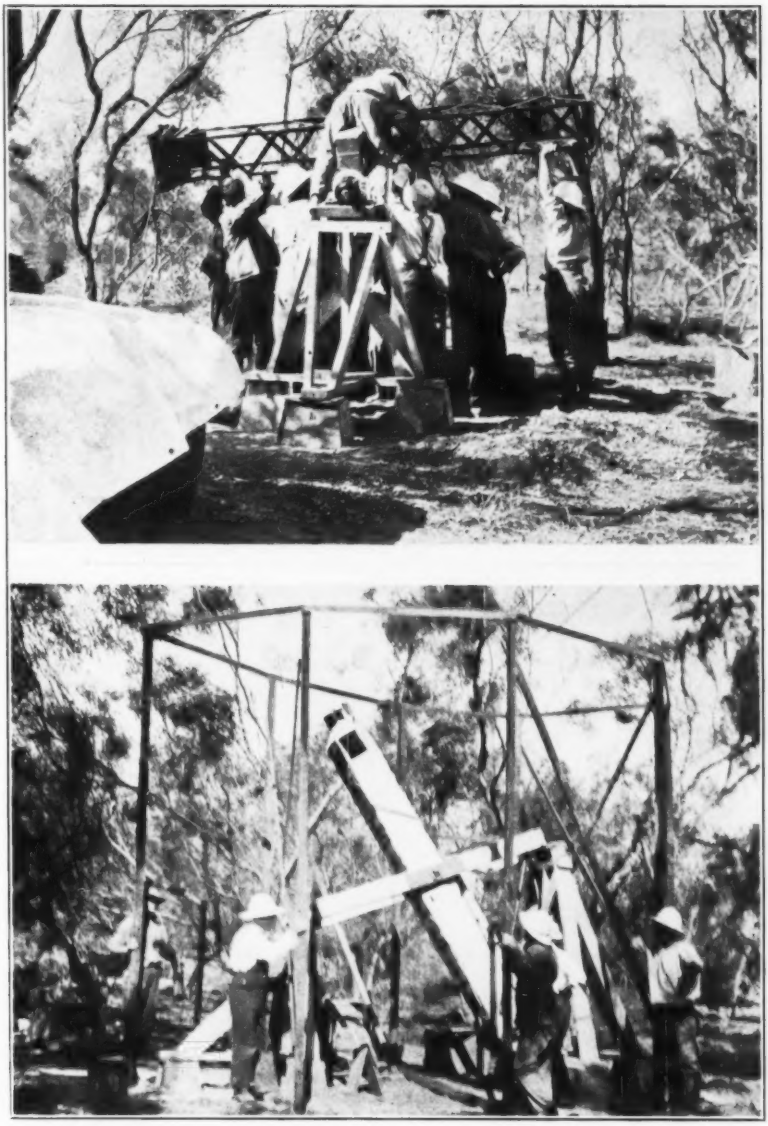
Solar Corona, September 21, 1923. Taken at Wallal, W.A. Upper photograph with lens of f = 33¾ in.; exposures 10 sec. (left) and 20 sec. (right). Lower, with lens of f = 36 in. and Nicol prism before it. Nicol turned through 90° between exposures, each of which was 5 sec.



Scientific Part of the Eclipse Expedition, taken at Perth, August 18, 1922.

Standing from left to right: Maxwell Quick, Hargreaves, Hosking, Trumpler, Dwyer, Nossiter, Matthews, Yeates, Moore, Nunn.
Sitting: Miss Chant, Mrs. Adams, Adams, Mrs. Campbell, Campbell, Mrs. Chant, Chant, Ross, Young.

PLATE IV.



Upper: Placing the Einstein Camera in the Polar Axis. Lower: The Camera mounted and tube covered. Framework in place for receiving cotton duck covering.

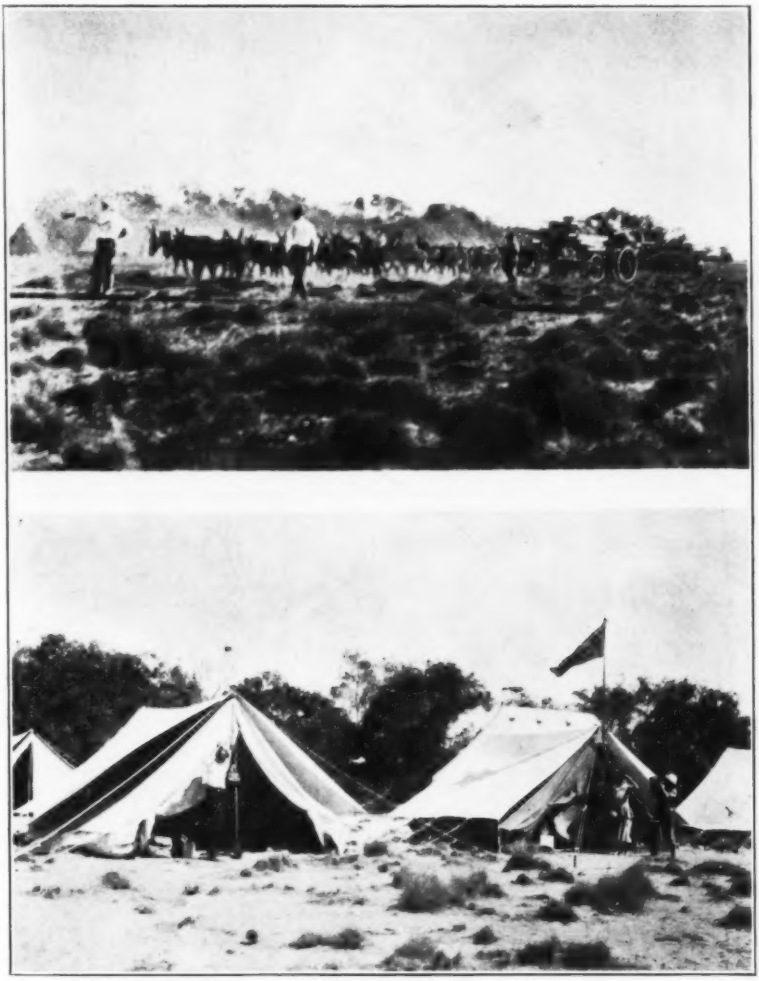
Journal of the Royal Astronomical Society of Canada, 1923.

PLATE V.

Upper: Naval Party. Standing from left to right: Sinclair, Hutchins, Barker, Cushing, Kenny. Sitting: Rhodes, Com. Quick, Starling, Kean.
Lower: Lick Observatory 40-ft. camera and, at the right, shelter for Einstein Cameras.

Journal of the Royal Astronomical Society of Canada, 1923.

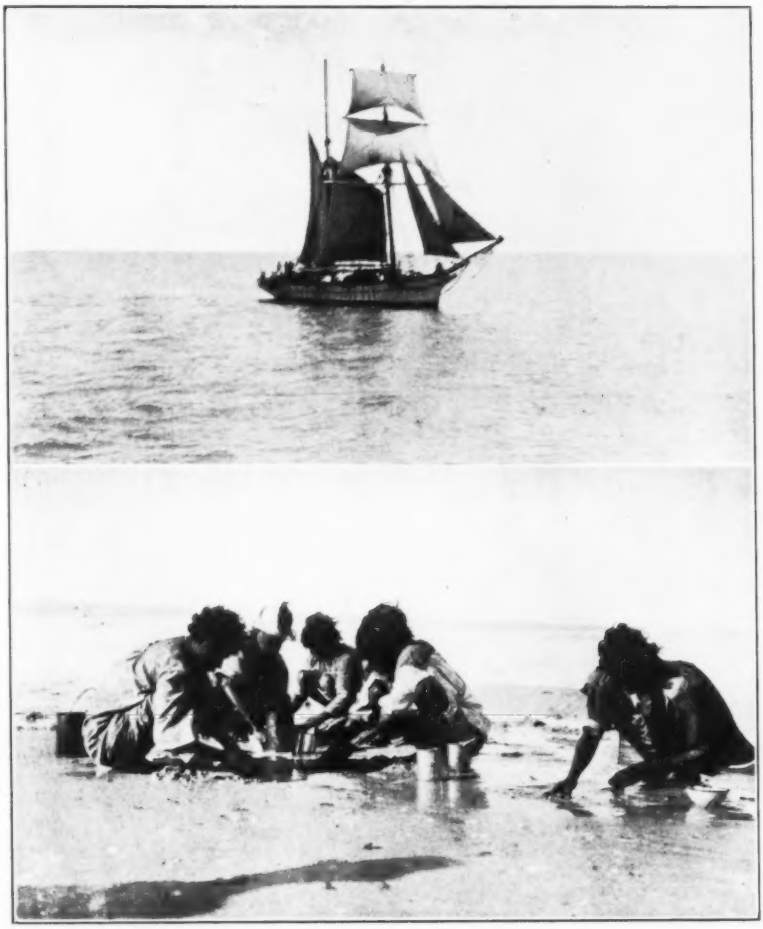
PLATE VI.



Upper: the 26-donkey team bringing in a load from the beach. Note the dust. Lower: the tents occupied by the Canadian Party. In both pictures clumps of spinifex are seen in the foreground.

In the upper photograph is shown the process of unloading and loading the whaleboat in the surf. Lower: aboriginal water-carriers at the well—a little gossip before starting for the camp 500 yards away.

PLATE VIII.



Upper: the schooner "Gwendoline". Lower: Aboriginal women gathering mussels on the beach.

THE JOURNAL
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VOL. XVII JANUARY-FEBRUARY, 1923 No. 1

THE ECLIPSE CAMP AT WALLAL

By C. A. CHANT

THE site chosen for the camp was about one and a half miles from the sea. It was covered with a very light loam and was bordered on three sides with wattle trees, which seem able to exist with the minimum of moisture. The soil was very dry and finely pulverized, and when one walked over it a cloud of dust rose behind him, and, being carried by a land or a sea breeze, would penetrate everywhere and settle on everything. We found it wise to dispense with table-cloths and some other accompaniments of good housekeeping. About one quarter of a mile to the south was the Government well. It was constructed in 1875 by Alexander Forrest, one of Australia's great explorers, when he was preparing a route near the west coast for driving cattle southward on the way to market. It is only 16 feet deep, the water is excellent and it never fails. Indeed we were told that Wallal means "good water" or "abundant water". Another quarter mile south is the post office and telegraph station. Why locate a telegraph station in this deserted country? The reason given was that it was necessary to have a line-repairer near here so that when any accident to the line occurred it might be repaired with little delay. Much of the country about is covered with red sand, on the surface of which, as well as at a depth of at least two feet, shells were found

quite like those on the shore of the ocean. Our altitude was about 30 feet and it would thus appear that we were on a raised sea-beach.

The camp was in longitude 120° 41′ E. and latitude 19° 46′ S. About three miles away was a small sheep farm, or "station", as it is called in Australia; some twenty miles off was a larger one; and at a distance of 66 miles was a large and important station. The area of some of these sheep or cattle stations is immense. I talked with a gentleman on board our ship who had 600,000 acres near Roebourne in Western Australia, but the largest of all is in Queensland and contains 60,000 square miles or 38,000,000 acres. The land itself, however, is very poor, requiring 5 to 10 acres to maintain one sheep. It was not at all unusual for a station to contain 30,000 or 80,000 sheep, and the monster estate in Queensland carries 250,000 cattle and many thousand horses.

After the great State Luncheon at Perth on August 17 the scientific members of the expedition were photographed in the rear of the Parliament House (Plate III). The Lick Observatory Party comprised Director and Mrs. Campbell, Dr. J. H. Moore and Dr. R. J. Trumpler from Mount Hamilton, Cal.; Dr. and Mrs. C. E. Adams, of Wellington, N.Z.; Mr. J. B. O. Hosking of Melbourne Observatory and Prof. A. D. Ross of the W. A. University, Perth. Messrs. J. Hargreaves and G. S. Clark Maxwell made up the English party. From Western Australia were Messrs. C. Nossiter (Chief Assistant in Perth Observatory), V. J. Matthews, G. M. Nunn, C. S. Yeates and J. J. Dwyer. In the Canadian party were Prof. C. A. Chant, Mrs. Chant and Miss Elizabeth H. Chant of Toronto, and Dr. R. K. Young, of the Astrophysical Observatory at Victoria, B.C. At Broome we were joined by Dr. and Mrs. John Evershed, of Kodaikanal Solar Observatory, South India, and they were assisted by Mr. D. Everson, of Perth. Each party was quite independent of the others and had its own programme, but Dr. Campbell was considered to be the leader of the whole.

The members of the Naval Party were Lieut.-Com. H. L. Quick, Warrant Officer W. S. Rhoades and Messrs. W. Kenny, L. W. Starling, F. Sinclair, H. Hutchins, J. Barker, S. Cushing, T. Roberts and J. R. Kean. They were mostly Chief Petty Officers and Petty Officers. In addition, there were two "movie"

men, Messrs. E. Brandon-Cremer and C. Sharpe, of Adelaide; and also Mr. Dewar, of Broome, the policeman for this district.

With the least possible delay the naval men prepared the camp for occupation. There were twelve tents for sleeping in, two large mess-tents, two store-tents and the cook's galley. The locations for the different parties were soon arranged. The Lick party settled among the wattle trees east of the tents and the Canadian party took the adjoining space just south of them so that both parties might hear the same time-announcer during the eclipse. The English party went some distance north-east and the party from India a short distance west. The Perth party went to the sheep station, three miles away.

By observation north-and-south lines were laid down, and the places for the foundations were then pegged out. Professor Ross had telegraphed ahead orders for broken stone and it was ready for us. There was plenty of good sand near the well and we had brought cement with us. The aborigines carried the stone and sand and water and in a very few days the cement foundations were constructed. At the same time the instruments were taken from their cases, put together and got ready for erection when the foundations had hardened sufficiently. In the case of some of the Lick instruments chains and pulleys were required to lift them.

Our chief instrument was the Einstein camera. The "tube" was 13 inches square and 11 feet long. The corner-strips were of angle-iron and it was made strong and rigid by truss-work braces as shown in the picture (Plate IV). To render it portable it was cut into three portions, each of which fitted its own packing-case. It could be put together or taken to pieces in perhaps an hour. For its design and the working drawings from which it was made thanks are due to Prof. C. R. Young, of the Faculty of Applied Science and Engineering. The plate-holders were of aluminium and were made with great care so that when any one of them was in the camera the front surface of the plate should be at the same distance from the lens. The camera was built by the Consolidated Optical Co., at Toronto. The plates used in testing for the Einstein effect were of plate-glass, 3/16 inch thick, specially supplied by the Eastman Kodak Co., of Rochester. The emulsion was "Seed 30". The camera was covered first with heavy farmer's satin

and then with rubber sheeting. The lens, which was made by Brashear, had a clear aperture of 6 inches and a focal length of 11 feet, and it weighed 37½ pounds. The camera tube weighed about 250 pounds.

The polar axis consisted of a rectangular wooden frame 8 feet long and 23 inches wide (outside measurement) and 6 inches deep. The frame was made from hard maple, three strips 6 inches wide and 7/8 in. thick being glued and then bolted together. It is seen in Plate IV. At the lower or north end the steel axis was 1 7/16 in. in diameter, that at the upper or south end was 1 3/16 in., and they turned in S.K.F. bearings.

The piers, or supports, at the two ends were made of pine, except the tops, which were of hard maple. They were bolted and screwed together, and when taken to pieces were packed in a single box.

The camera was held in declination by an iron rod having one end fastened to the camera and the other to the wooden rectangle. A slot at the camera end allowed a certain amount of change in declination, but during the observations the rod was clamped tight, that is, the declination was fixed.

The camera was moved in right ascension by a clock (made by Cooke) mounted on the inner face of the lower pier. The worm-wheel, which could be clamped to the axis, is seen in the photograph. There was a differential slow motion on the clock which was operated by means of a cord held by the observer at the plate-end of the camera, as he looked into the guiding telescope. This had an aperture of 4½ inches and a length of about 6 feet, and it was mounted on the camera in such a way that it pointed to Beta Virginis, which was about 2½° from the sun, when the sun was at the centre of the photographic plate.

To protect the camera from the wind and from direct sunlight a wall of cotton duck 14 feet high was built around it. The framework for this is seen in the photograph. This shelter also had a roof, which could be pulled aside for observations. In order to keep down the dust as much as possible the ground inside and around the shelter was covered with red sand carried to us by the aborigines Moses and Tommy,—father and son. Much of the time this sand was kept moist with water brought to us in empty kerosene cans by the same useful people.

A few feet east of the Einstein camera another polar axis was erected, on which were mounted two cameras, one of one inch aperture with a Nicol prism over it and the other one stopped down to give an equally bright image. The focal length of the former was 36 inches, of the latter 33¾. The object was to secure photographs in natural light and also in light polarized in different azimuths and with varying exposures. The plates were 3¼ by 5½, mostly of Seed Emulsion 30. Before being developed the plates were placed in a sensitometer behind a brass plate in which were holes near its edge of different sizes, and then exposed to a constant source of light for the same number of seconds as the photographic plate was exposed during the eclipse. In this way there were obtained spots on the plate of varying density which, by means of a photometer, could be compared with the photographs of the corona. The method is that used by Parkhurst at the Yerkes Observatory.

In addition, observations were made on the shadow-bands. By means of two ordinary cameras and one "movie" camera, attempts were made to secure photographs of these weird apparitions, but without success. Interesting visual observations, however, were secured. Two white sheets were stretched on level ground and a rod about six feet long, pivoted near its middle, was laid on each. One sheet was used for the bands before totality and the other for those after it. As soon as the bands appeared the rod was moved about so that its length was parallel to the crests of the waves.

Further, measurements of the general sky-light during totality were made by reading print of different sizes and also by exposing two photographic plates in the sensitometer. A photographic plate was exposed to the corona only, in an endeavour to determine its general brightness, but the plate was somewhat over-exposed.

Practically everyone had arrived at the camp by the evening of Thursday, August 31, but the last package of freight was not delivered until Saturday afternoon. By the following Saturday, September 9, the erection of the instruments was nearly completed and during most of the following week we were busy adjusting them. Every day we would make some little alteration or

improvement suggested by experience in handling them. The camera mounting was adjusted with great care in azimuth and altitude and the focus of the lens was determined by photographing the stars at night. The development of these test plates was done under difficult conditions. Mr. Owen, the line-repairer, offered us the use of his house, but we found it almost impossible to keep the developer and the fixer cool enough, and the gelatine films on the plates became soft and easily mutilated. Also there was much dust in the air which settled on the plates if they were placed in a current of air to dry and yet if they were not so placed but kept in a closed space the films required a very long time to dry and would sometimes flow under the high temperature prevailing. As a consequence Dr. Young and I decided that we would not attempt to develop our critical plates at the camp at all, but would take them to Broome, after the eclipse, and try to secure better conditions there.

For the first week the work went forward with anxious haste. At about 6.30 a.m. the camp would be roused by the musical voice of Mr. Rhoades, who walked amongst the tents shouting out an old getting-up call used on board ship. We would rise and don our working clothes, and by this time the sun would be up and the flies would begin to swarm about us. They were the ordinary house-fly though not so large as those we had left at home. But they were very annoying and we continually wore nets hanging from our hats. The continued motion of the net as we were working kept the flies away. However they always disappeared at sunset and allowed us to rest comfortably during the cool nights.

After an hour's work mixing cement or putting instruments together or making necessary alterations to apparatus we would have breakfast—a substantial and well-prepared meal—and then to work again! Lemonade was served in the mess-tent at 11 a.m. and lunch at 1 p.m. At 4 p.m. was the inevitable afternoon tea, and when darkness came on we would wash up for dinner at 7, eaten in peace after the flies had gone

At the end of a week the preparations were rather ahead of schedule time and we spent Sunday at the sea-shore, bathing in the surf and walking the beach in search of shells, many beautiful specimens of which we found. During the second week most of

the observations for adjustment were made at night, but as almost every night was clear good progress was made in this work. During the third week we held numerous rehearsals of our programme. Mr. James Kean, one of the Naval party, would stand on a box with a chronometer before him A certain second would be chosen for the beginning of the total phase, the zero hour, and at precisely six minutes before that epoch Mr. Kean would call out "Six minutes before!" Everyone would be at his post. Four minutes later he would call, "Two minutes before!" Then "Thirty seconds before!" Director Campbell would be looking through the finder of his Einstein camera and when he would (in imagination) see the moon just cover the sun and the corona flash out he would shout "Go!" Then Mr. Kean would count the seconds, One! Two! Three! . . . Fifty-nine! One minute! One! Two! etc., until some seconds after the time totality was supposed to end. This practice continued until the fateful day arrived, and then the last performance was enacted under perfect weather conditions.

Dr. Young and the writer handled the Einstein camera. He did the guiding and also assisted to insert the plate-holders and to remove them. Mr. William Owen, the telegraph-line repairman, removed and replaced the cap from the lens. The exposures with the two smaller cameras and the orienting of the Nicol prism were carried out by Miss Elizabeth H. Chant, while the plate-holders were handled by Messrs. L. Starling and F. Sinclair, of the Naval party. Mrs. Chant made observations on the shadow-bands; she also tested the brightness of the sky by reading type of different sizes, and exposed two plates to register the sky-light. The shadow-bands were very faint. They appeared about two minutes before totality and 15 seconds after. The general illumination was roughly equal to a candle at a distance of two feet. More accurate results will be given at a later time. In the evening one more exposure to stars was made and our observations were over!

Next day (Friday) we began to take down and pack up and by Saturday noon our last case was closed. They were transported to the beach as they had been brought up, namely, by donkey team. We slept at the camp for the last time on Sunday night. The navy warship *Geranium* reached Wallal, anchoring about seven miles out, ready to tow the *Gwendoline* back to Broome.

The schooner had arrived some days before. After some delay through heavy surf we at last got started. There were many interesting and amusing experiences before we were all stowed away and ready to go, but I have not space here to describe them.

We reached Broome on the morning of Thursday the 28th. Here we were entertained at the Palace of Bishop Trower and at the "Residency", the house of Colonel Mansbridge, the Resident Magistrate, and received many kind attentions from the citizens in general. Dr. Young's room at the hotel was made suitable for photographic work, and the Mayor, Mr. Clarke Hall, furnished an abundant supply of rain-water, while the local ice-making company made us ice from rain-water. In this way the developing of our plates was carried out with comparative comfort. We found that we had two Einstein plates of good quality; a third plate taken in the Einstein camera on a Seed 23 plate with a shorter exposure, not for the Einstein problem, was not quite so satisfactory. With the smaller cameras some 20 exposures were made and about 14 of the plates will be suitable for photometric measurement. The Einstein comparison plates had been secured through the generous assistance of Director Campbell. Dr. Trumpler went to Tahiti in April taking the Lick cameras with him. There he mounted them and secured the required night comparison plates in May and June. The Toronto camera was shipped to Tahiti in May. It was there placed in the Lick mounting, which it had been made to fit, and Dr. Trumpler obtained seven plates for comparison purposes. All the plates are being measured at the Dominion Astrophysical Observatory at Victoria, but it is impossible to state when the reductions will be completed and the results ready for announcement.

In closing this brief descriptive account of our work I wish to mention some bodies and persons to whom the expedition from Canada is indebted. The University of Toronto defrayed the quite considerable cost of the apparatus and of the freight on it to and from Australia. The University also made a generous contribution to the travelling expenses of the writer. The Dominion Government, with the approval of Director J. S. Plaskett, gave leave of absence to Dr. Young and also contributed to his ocean travel. The Council of the Royal Astronomical Society of Canada,

from its limited funds, made a generous grant to the writer towards the expenses of the expedition. However, in view of the urgent need of better accommodation for the headquarters of the Society, this has been returned, with the request that it be added to a building fund started some years ago, but which has grown very slowly lately. But especial acknowledgment should be made of the assistance and hospitality received in Australia. The Federal Government provided the transport of the expedition from Sydney across the continent to Freemantle by rail and thence to Wallal by water, steamer and schooner; and, after the eclipse, the return to Sydney. This Government also supplied the men from the Royal Australian Navy who put up the camp, provided our sustenance and assisted in the erection of the instruments. This was indeed a great service and was fully appreciated by all the members of the expedition. The Governments of the states, and of the cities at which we stopped gave us a cordial and generous welcome which will always remain a bright incident in our lives. In addition many valued personal friendships were made. Indeed everyone we met seemed anxious to render us all possible help to make our expedition pleasant and successful. It was the experience of a life-time.

WIRELESS TIME SIGNALS OBSERVED AT OTTAWA

By R. Meldrum Stewart

THE signals were observed by the method of coincidences by extinction, in which the points of a relay operated by an auxiliary chronometer with a differential rate are inserted in the aerial circuit. For the Annapolis signals (mean time) the auxiliary chronometer was rated to gain about 15 minutes per day; for the Lafayette signals a sidereal chronometer was used. The chronometer was in each case chronographically compared, shortly before and shortly after the receipt of signals, with the standard sidereal clock. The observers taking part in the receipt of signals at various times were Messrs. Dier, Henderson, Smith and Stewart.

The results for the Annapolis signals have been corrected for the errors of the Washington clock, as given in the monthly lists distributed by the U.S. Naval Observatory, as well as for the adopted lag of Annapolis (.08 sec.).

For the Lafayette signals the times of the first and last beats (in Greenwich sidereal time) have been computed from the mean of the observed coincidences by the use usually of the observed mean daily rate of the transmitting clock, as deduced from the intervals between corresponding signals on consecutive days.

The Ottawa times have been derived from a smoothed curve of observed clock-corrections, account being taken of daily comparisons of the two Riefler clocks. The observed clock-corrections, as well as the adopted values for each day at 10 p.m. (15h G.M.T.) are given in the last two columns.

The adopted longitude of Ottawa is 5h 2m 51.940s; no correction has been made for time of transmission of the signals.

Dominion Observatory,
Ottawa, December, 1922.

1922 Date	Ottawa—Washington 5h G.M.T.	15h G.M.T.	Lafayette (G. Sid. T.) 1st beat	300th beat	ΔT at 10 p.m. Observed	Adopted
	s	s	h m s	h m s	s	s
July 1	−.01	−.04				+8.699
2	−.01	.00				+8.741
3	−.02	+.01	14 48 10.53	14 53 4.06		+8.774
4	.00	+.01	53 13.46	58 6.98	+8.811	+8.788
5	−.04	−.03	55 19.51	15 0 13.03	+8.777	+8.797
6	−.01	−.04	15 2 19.88	7 13.40	+8.820	+8.828
7	−.05	−.06	3 27.20	8 20.72		+8.869
8	−.08	−.06			+8.921	+8.912
9	−.07	−.08	12 34.15	17 27.68		+8.943
10	−.10	−.10			+8.966	+8.969
11	−.13	−.12	20 42.19	25 35.71		+9.002
12	−.12	−.10				+9.043
13	−.13	−.09			+9.072	+9.095
14	−.10	−.10			+9.156	+9.149
15	−.07	−.10			+9.206	+9.201
16	−.12	−.08				+9.260
17	−.12	−.07				+9.265
18	−.11				+9.292	+9.269
19	−.10	−.06			+9.196	+9.226
20	−.07	−.10	53 21.94	58 15.46	+9.221	+9.234
21	−.10	−.10	59 24.76	16 4 18.29	+9.245	+9.246
22	−.10	−.08				+9.270
23	−.09	−.04				+9.267
24	−.08	−.06	16 12 41.82	17 35.35	+9.252	+9.254
25	−.10	−.07			+9.260	+9.253
26	−.10	−.08	19 54.77	24 48.31	+9.257	+9.255
27	−.08	−.06	24 59.70	29 53.23		+9.250
28	−.06	−.06			+9.250	+9.257
29	−.09	−.05	34 10.75	39 4.28	+9.250	+9.255
30	−.10	−.10				+9.247
31					+9.239	+9.236

1922 Date	Ottawa–Washington 5h G.M.T.	Ottawa–Washington 15h G.M.T.	Lafayette (G. Sid. T.) 1st beat	Lafayette (G. Sid. T.) 300th beat	ΔT at 10 p.m. Observed	ΔT at 10 p.m. Adopted
	s	s	h m s	h m s	s	s
Aug. 1	−.10	−.08				+9.230
2	−.10	−.08				+9.223
3	−.04	−.06				+9.203
4	−.06	−.05			+9.194	+9.197
5	−.10	−.08			+9.162	+9.180
6	−.08	−.08				+9.144
7	−.08	−.05			+9.123	+9.106
8	−.07	−.05			+9.029	+9.072
9	−.04		17 18 33.28	17 23 26.81	+9.062	+9.056
10	−.03	.00	18 45.39	23 38.93	+9.045	+9.024
11	−.01	+.01	26 48.49	31 42.03	+9.002	+9.008
12	−.02	−.01	28 58.09	33 51.62		+9.003
13	−.02	−.01	32 6.54	37 0.07		+8.984
14	−.03	−.02			+8.929	+8.955
15	−.05	−.05			+8.964	+8.942
16	−.10	−.06			+8.908	+8.911
17	−.07	−.05				+8.893
18	−.07	−.10				+8.880
19	−.11	−.07				+8.860
20	−.10	−.09	58 40.55	18 3 34.09		+8.817
21	−.06	−.08				+8.780
22	−.07	−.04	18 7 57.18	12 50.72		+8.744
23	−.05	−.07	11 6.66	16 0.20	+8.694	+8.700
24	−.06	−.04				+8.673
25	−.08	−.05				+8.643
26	−.08	−.09			+8.615	+8.610
27	−.11	−.10	29 37.37	34 30.90		+8.568
28	−.11	−.12			+8.532	+8.551
29	−.12	−.09	35 55.74	40 49.28	+8.538	+8.547
30	−.11	−.09	39 27.64	44 21.18	+8.541	+8.537
31	−.08	−.07			+8.534	+8.521

ASTRONOMICAL SCIENCE AND MODERN PHILOSOPHY[1]

By Joseph F. Heffron

PHILOSOPHERS, as a rule, dwell in heights that are inaccessible to the great multitude; their systems and conclusions are the most difficult of all sciences to popularize. I therefore confess to a certain tremor at the audacity of the enterprise I am about to undertake, since any attempt at a discussion of so abstruse a subject as the *Theory of Relativity* presupposes a high degree of technical skill on the part of the lecturer. Indeed, some mathematicians, in referring to Einstein's representation of a so-called *Elliptic Interval*, have described it as a very weird construction, and apparently the person who will make it apprehended by the average student of the theory is yet to be born.

When Lord Byron said:

> "And Coleridge too, has lately taken wing,
> But like a hawk encumbered with his hood,—
> Explaining Metaphysics to the nation—
> *I wish he would explain his Explanation.*"
> *Dedication to "Don Juan".*

he had still a sure footing in intelligibility compared with the non-mathematician, who demands an explanation for such a construction as the one I have just referred to.

I am not so presumptuous, therefore, as to profess to you that I understand that complex of thought and research, which in physics has culminated in our day in that complicated and bizarre generalization concerning time and space which has come to be known as the *Theory of Relativity*,[2] and which promises to give to us an entirely new view of the universe in which we live. I am simply desirous of presenting to you some thoughts, some side-

[1] A paper read before the Royal Astronomical Society of Canada, at Toronto, April 4th, 1922.

[2] See Article entitled *Time, Space and Gravitation*, by Albert Einstein, in *Science*, of January, 1920. See also, *Time, Space and Gravitation*, by A. S. Eddington, 1920.

lights, on certain phases of the theory, which I have found interesting, and it is my earnest hope that during the course of the hour at my disposal, I shall be able to present these ideas to you in such manner, that you may also find in them something of interest.

As Lecky says in the preface to his History[1] concerning "the habit of thought which is the supreme arbiter of the opinions of successive ages, those who have contributed most largely to its formation are, I believe, the philosophers."

It is undoubtedly a fact that the philosophic systems that prevail in the academies of each successive age exercise a profound influence upon the whole thought of their generation. They impart a tone and give a point of view to the large army of popular writers, poets, historians, scientists, and others, who mediate between the multitude and the select group of wisdom-seekers.

The thoughts and ideas formulated by Galileo, Laplace, Newton, and Darwin, have done much to set the current of their respective ages. They have assisted in the formation of a certain cast and tone of mind. They have introduced certain peculiar habits of thought, new modes of reasoning, new tendencies of inquiry. The impulse they have given to the higher literature has been by that literature communicated to the more popular writers and lecturers, who spread the new doctrines over a still wider field, until the impress of these master-minds is clearly visible in the writings of multitudes totally unacquainted with the original works.

Einstein's *Theory of Relativity*, with its varied implications, is now passing through this stage. New philosophical ideas are seldom widely popular, and as in 1850, before the intervention of Darwin, the hypothesis of organic evolution was much in the same position as the Copernican hypothesis in the sixteenth century before the appearance of Galileo, so in our own age and time the notion of *Relativity* will probably remain a highly precarious speculation until continued observation and research either catalogues it as one of the facts known to science, or relegates it to the limbo through which many curious theories have passed on their way to oblivion.[2]

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[1] *The Rise and Influence of Rationalism in Europe.* William Hartpole Lecky, p. viii.

[2] See *The Idea of Progress.* J. B. Bury, 1920, pp. 334-335.

For the time being the world at large is puzzled by the strangeness of the conceptions involved in the theory, but should further investigation continue to support it, the theory will probably run through the classic stages of a theory's career: "First, . . . a new theory is attacked as absurd; then it is admitted to be true, but obvious and insignificant; finally it is seen to be so important that its adversaries claim that they themselves discovered it."[1]

The time will probably come when the theory will creep into our text-books, and, no longer strange or curious, it will become a part of every well-instructed person's education. Its adoption will give a wider perspective of the universe to the average mind, and it promises to illuminate certain dark corners and explain certain puzzling phenomena hitherto incapable of explanation. Physics and Astronomy will thus find the theory useful, and in a broader way, the soul of man, inspired with new courage, will proceed still further in the never-ending attempts at solution of the many riddles that face us at every turn and are ever pressing for interpretation.

The Eclipse Observations of 1919

The British astronomers who went to Africa and to South America to observe the eclipse of the sun, May 29, 1919, for the purpose of determining what effect, if any, is produced by a gravitational field on the path of a ray of light traversing it, returned to England with a few photographs which, when compared with reference photographs of the same star-fields taken at night, seemed to indicate that a ray of light passing close by the sun is bent out of its supposed straight course, thus overturning all our former notions concerning the phenomena and characteristics of a ray of light.

Upon the announcement of this startling result before the Royal Society in London, November 6, 1919,[2] enterprising news-

[1] See *Pragmatism*. William James, 1916, p. 198.

[2] See *A Determination of the Deflection of Light by the Sun's Gravitational Field*, from observations made at the total eclipse of May 29, 1919, by F. W. Dyson, astronomer royal, A. S. Eddington and C. Davidson. *Philosophical Transactions of the Royal Society of London*, Series A, vol. 220, pp. 291-333.

paper reporters commenced interviewing astronomers and physicists in every part of the globe, and the pages of many of our newspapers were devoted to interesting speculations on the nature of space and time as well as to political affairs and the condition of the world's markets.

The printing presses of the world soon added to the literary deluge of the times by turning out "Primers in Einstein," and parlour philosophers discoursed learnedly upon the new theory which was even given popular expression in our music-halls by the verse:

> "A warp in Nature has been found,
> No line is straight, no circle round,
> For Isaac Newton had unsound
> Ideas of gravitation."[1]

When the photographic plates taken at the time of the eclipse were compared with the night plates of the same star-fields, it was found that the star-images near the darkened disk of the sun on the eclipse plates did not exactly coincide with the position of the star-images when the sun was not in their midst, (relatively in their midst, of course), but showed an abnormal shift of less than 11324,000th of a right angle.

Careful measurement of the displacement of these stellar bodies from their ordinary positions showed the displacement to be 1.60 seconds of arc on the African plates and 1.98 seconds on the Brazilian plates. When we average these two observations the result is 1.79, which is extremely close to the 1.73 predicted by Einstein and double the amount of deflection arrived at when our calculations are made in accordance with Newton's law, which gives us .87 of a second.

It should be noted that the observations we have referred to were not altogether satisfactory. At Principe, an island off the West Coast of Africa, a cloud drifted by at an inopportune moment, and only a few photographs were obtained. One of the object glasses used at Sobral, in Brazil, gave distorted images, but a very good series of seven star-images was obtained with the other glass used. Measurements made from these star-images at the Royal Observatory and at Cambridge result in the following figures,

[1] Quoted in *Easy Lessons in Einstein*, Edwin E. Slosson, 1921, p. 1.

which are closely in accordance with those calculated by Einstein's formula:

RADIAL DISPLACEMENT OF STARS[1]

As obtained by the British Expedition:						
0.20	0.32	0.56	0.54	0.84	0.97	1.02
As predicted by Einstein:						
0.32	0.33	0.40	0.53	0.75	0.85	0.88

The astronomers of the British Eclipse Expedition have expressed themselves as being of the opinion that the results of the expeditions to Sobral and Principe can leave little doubt that a deflection of light takes place in the neighbourhood of the sun and this deflection is of the amount demanded by Einstein's generalized *Theory of Relativity*. Whoever hesitates to accept so disruptive and far-reaching a theory on the basis of calculations so limited and minute must await the results of further measurements to be made from the observation of the eclipse that will occur in Australia later this year.

It has been suggested by some of the opponents of Einstein's theory that the deflection of light observed in the stars near the sun's disk may result from a solar atmosphere which causes a refraction of the rays of light as does the envelope of air that encircles our own planet. Others suggest that the deflection may be due to the presence of coronal matter, while still others maintain that it is highly improbable that an enveloping atmosphere or even coronal matter sufficiently dense and extending out far enough to produce such an effect would have remained unobserved. Dealing with this objection the members of the British Eclipse Expedition state that the effect described "*must be attributed to the sun's gravitational field and not . . . to refraction by coronal matter.*" In order to produce an effect by refraction similar to that observed, we are informed that the sun must be surrounded by material having a refractive index of $1.00000414/r$, where r is the distance from the centre in

[1]Quoted from *A Determination of the Deflection of Light by the Sun's Gravitational Field*, from observations made at the total eclipse of May 29th, 1919, by F. W. Dyson, astronomer royal, A. S. Eddington and C. Davidson. *Philosophical Transactions of the Royal Society of London*, Series A, vol. 220, pp. 291-333.

terms of the sun's radius. The necessary refractive index 1.00000212 at a height of one radius above the surface would correspond to that of air at 1/140 atmosphere, hydrogen at 1/60 atmosphere, or helium at 1/20 atmospheric pressure. The members of the British Expedition believe that a density of this order is out of the question and it is highly improbable that such an atmosphere should have almost exactly the density and decrease with the distance at just the rate necessary to produce the deflection predicted by Einstein's calculations.

It is hardly necessary to point out that the situation created by these observations is somewhat disconcerting to astronomers. For the past three hundred years all their calculations with regard to stellar bodies have been based upon the assumption that light travels *in vacuo*, through empty space, *i.e.*, the ether, in straight lines and at even speed. If the force we know as gravity deflects a ray of light from its supposed straight course when the ray passes near a massive body, it is possible that light rays reaching us from a distant stellar body after traversing the tangled throng of the Milky Way, may have travelled a very devious course indeed before reaching us, and consequently the stellar body from which the light comes might really be located in an entirely different position than the one apparent to us. There is also the possibility that a stellar body which appears to us as a binary may actually be a single body, and that rays projected from it in different directions may be deflected by other stellar bodies so that when these rays reach us they have the appearance of coming from different points in space.

Does Light Have Weight?

This apparent deflection of a ray of light when passing near a massive body has led to the conclusion that light has weight. Assuming that its deflection is a fact, it must have weight, it must be ponderable, otherwise so far as our experience extends, it could not be deflected. This discovery, if it be a fact, Edwin E. Slosson[1] informs us, results in some startling conclusions.

[1] *Easy Lessons in Einstein*, p. 95.

For example, what shall be done with Newton's law that action and reaction are equal? When a gun is fired the kick of the gun is balanced by the momentum of the projectile. When a reflector throws a beam of light into space, the kick of it is there all right but where is the projectile, if light is merely the undulation of an imponderable fluid? We may suppose that the light strikes some dark body out in space, transmits its impulse to that and Newton's law is satisfied, but it may be a long time before such a body is encountered and it may never be; at any rate a law that remains in a state of innocuous desuetude for several thousand years is not good for much.

It follows, therefore, that we must conceive of light as having mass since it apparently has inertia and momentum, and having mass, light must also have weight, *i.e.*, it is attracted by gravitation. This exceedingly startling deduction has apparently been confirmed by the eclipse observations made in May, 1919.

It would seem that Newton, when formulating his corpuscular or emission theory, had some idea that light has weight. We find the following in his *Opticks*:[1]

QUERY 1.—Do not Bodies act upon Light at a distance, and by their action bend its Rays, and is not this action (caeteris paribus) strongest at the least distance?

While Newton's emission theory seemed to have passed into oblivion forever after having had its day, it would seem that in the light of the evidence now being presented, we shall again have to adopt it in some modified form if we are to explain the facts.

Nineteenth century physicists had come to regard light as merely a form of motion in a weightless medium, the ether. Disembodied energy, like heat and light in ethereal space, was regarded as having no mass or weight..

Twentieth century physicists seem to be coming to the opposite view, that the mass of a body is the measure of its internal energy.[2] If so, mass is not constant, but changes with composition, temperature, structure, electrification, and motion.

EINSTEIN'S THEORY

In the brief paper[3] of four or five pages in which he proposed

[1] Quoted by A. S. Eddington, in *Contemporary Review*, December, 1919.

[2] See *The Mystery of Matter and Energy*, by Albert C. Crehore, 1917; also Lecture on *Twentieth Century Physics*, by R. A. Millikan, *Proceedings of the American Institute of Electrical Engineers*, September, 1917.

[3] In the *Annalen der Physik*, 1905.

his new theory of the universe, Einstein based his theory upon two postulates.

The first was the *principle of relativity*, *i.e.*, that all motion is relative. As everyone knows, paths in which bodies appear to travel depend on whether the observer is at rest or in motion on his own account, and the velocity which we attribute to the body will depend on the body relatively to which the distance travelled is measured and on the measurement of time adopted.

Therefore, if you take all motion to be relative, you cannot speak of *the* direction or *the* velocity of a body, since no body can have a unique direction or velocity. Each will have dozens of different and equally good velocities and directions according to the bodies relatively to which its motion is determined. Similarly for the measurement of time. Time is measured by the recurrence of certain events, and, according as you take different processes to be uniform you will reach different results as to the uniformity or lack of it in a given motion. Newton undoubtedly recognized this distinction. He distinguished between absolute space, time, and motion, and relative spaces, times, and motions, admitting it to be possible that no change was uniform and therefore capable of giving a measure of absolute time, and that no body was absolutely at rest or in uniform absolute motion in a straight line. He thought, however, that he could give a criterion of absolute motion, and by experiment, prove the reality of, at any rate, absolute rotation. Most philosophers, nevertheless, have a strong objection to the idea of absolute motion, space or time, and even putting this prejudice aside, there is felt to be a reasonable doubt whether it can be necessary or possible to start—as mechanics presumably does—from empirical data to reach laws which are stated in terms of two entities which certainly cannot be perceived, and then to return and explain empirically perceived motion by means of these laws.[1]

As a simple illustration of this idea we would have an instance of it were we to ride in a smoothly moving vehicle in which the windows had been darkened so that we would have no sense of motion. Under such conditions it would be impossible for us to

[1]See *The Reign of Relativity*, by Viscount Haldane, 1921, pp. 82-118.

discern the forward motion of either the vehicle in which we were riding, or on a broader scale, the motion of the earth, since we would be unable to see the other bodies about us or in the heavens by which we are able to determine our relative movement. All movement is for us simply movement in relation to other objects, either about us or in space.

The second postulate proposed by Einstein was that *the velocity of light is independent of the source.* This postulate is an extremely difficult one for our reason to credit, since it implies that nothing is capable of moving more rapidly than the speed of light, or about 186,330 miles a second, and that it is an impossibility to make light travel at a higher speed than this by giving it a swift send-off.

Without involving ourselves in a lengthy discussion on this point we may say briefly that physicists owe their confidence in this proposition to the Maxwell-Lorentz theory of electro-dynamics.

More simply stated, it is the same as saying that if one were to stand upon the pilot of a locomotive, and from that position threw a ball forward, the velocity of the ball would not be affected, whether the locomotive moved forward or backward at full speed or remained in a stationary position.

The experiments of the American physicists, Michelson and Morley,[1] who measured the speed of light and found the speed to be constant whether the earth moved toward the source of the light-ray or away from it, or at right angles to its direction, support this second assumption by Einstein.

The acceptance of Einstein's two primary postulates, together with his later *Principle of Equivalence,* are of assistance in clearing up a number of difficulties that have baffled scientific men for some time past. It is claimed that the theory explains the motion of the perihelion of the orbit of the planet Mercury that cannot be entirely accounted for with Newton's theory. It forecasted the startling phenomena of the deflection of light by the sun's gravitational field, and while a third prophecy, that of the shifting of the lines of the solar spectrum towards the red end, has not yet been met, it is hoped that further observation and experiment will either confirm or disprove this supposition.

[1]See *Light Waves and their Uses,* Albert A. Michelson, 1903; also *Am. Jour. Sci.*, vols. 22 (1881), and 34 (1887).

Technical points of this character are exceedingly interesting to physicists and astronomers, but for the average layman, the theory carries with it certain bizarre and curious speculations as to the nature of time and space that it will be interesting for us to consider for a few moments.

The Relation of Space and Time

Glancing down the vast avenues of history we see that philosophic thought has been concerned with the problem of the relation of space and time for many centuries. In the suburban groves of Athens and in the cool *atria* of patrician mansions on the Palatine and the Pincian, men such as were Plato and Aristotle, Zeno and Plotinus, wrestled with the question of the finiteness or infiniteness of space, they carried on discussion as to whether length is absolute or relative, whether time and space have real existence or are merely conceptions of the human mind, *i.e.*, a form given to the events of nature by the character of the human mind, that is, to the hypothetical cause of our sense perceptions. And these questions have formed a never-ending topic for philosophical discussion until the present day.

Many different types of mind have concluded that space and time have no absolute existence, but are as the philosopher Kant believed,[1] categories, *i.e.*, mere forms in which the human mind conceives its relation to nature. More than this, many modern philosophers do not believe as did Kant, that space and time are intuitions, but rather that our ideas in this respect are constructions as patently artificial as any that science can show.

In his immortal *Faust* the poet Goethe gives expression to this same idea in his reference to the marriage of Achilles and Helen as having occurred "outside of all time." In the Book of Revelations we find mention of "when there should be time no longer." More recently we find the great mathematicians of the 19th century, Gauss, Riemann, Lobatschefsky, and Bolyai, expressing the view that space is not an empirical deduction from nature, but a conception of the mind. This view is supported by the fact that

[1] See Kant's teaching about time and space which is contained in two portions of the *Kritik of Pure Reason;* in Pt. I the Æsthetic and in the first and second *Antinomies* of Pt. III.

the human mind is able to conceive of various forms of space, each differing from the other, and differing from the form in which the mind of man has cast the events of nature (the Euclidian space). If we adopt the *Theory of Relativity* the same conclusions follow, space and time do not exist in nature by themselves as empty space and empty time, but owe their existence to things and events as they occur in nature.

Steinmetz observes that space and time are relative in the relation between ourselves and the events of nature, so much so that they are not fixed and invariable in their properties, but depend upon the observer and the conditions of observation.[1]

We have an illustration of this idea of relativity in the following quotation from Maeterlinck's *Our Eternity*,[2] in which the great Belgian writer directs the attention of his readers to a

striking passage in which Sir William Crookes shows how well-nigh all that we consider as essential laws of nature would be falsified in the eyes of a microscopic man, while forces of which we are almost wholly ignorant, such as surface-tension, capillarity, the Brownian movements, would preponderate. Walking on a cabbage-leaf, for instance, after the dew had fallen, and seeing it studded with huge crystal globes, he would infer that water was a solid body which assumes spherical form and rises in the air. At no great distance, he might come to a pond, when he would observe that this same matter, instead of rising upwards, now seemed to slope downwards in a vast curve from the brink. If he managed, with the aid of his friends, to throw into the water one of those enormous steel bars which we call needles, he would see that it made a sort of concave trough on the surface and floated tranquilly. From these experiments and a thousand others which he might make he would naturally deduce theories diametrically opposed to those upon which our entire existence is based.

If we consider for a moment the illustration imagined by the American philosopher William James,[3] we find that it would be the same were the changes made in the direction of time.

Suppose we were able, within the length of a second, to note distinctly ten thousand events instead of barely ten, as now; if our life were then destined to hold the same number of impressions it might be a thousand times as short. We should live less than a month, and personally know nothing of the change of seasons. If born in winter, we should believe in summer as we now believe in the heats of the carboniferous era. The motions of organic beings would be so slow to our senses as to be inferred, not seen. The sun would stand still in

[1] See an article entitled: *Science and Religion*, by Charles P. Steinmetz, *Harper's Magazine*, March, 1922, pp. 296-302.

[2] *Our Eternity*, Maurice Maeterlinck, 1914, pp. 238-239.

[3] See *Our Eternity*, pp. 239-241.

the sky, the moon be almost free from change and so on. But now reverse the hypothesis, and suppose a being to get only one thousandth part of the sensations that we get in a given time, and consequently to live a thousand times as long. Winters and summers will be to him like quarters of an hour. Mushrooms and the swifter growing plants will shoot into being so rapidly as to appear instantaneous creations; annual shrubs will rise and fall from the earth like restlessly boiling water-springs; the motions of animals will be as invisible as are to us the movements of bullets and cannon-balls; the sun will scour through the sky like a meteor, leaving a fiery trail behind him, etc. That such imaginary cases (barring the super-human longevity) may be realized somewhere in the animal kingdom, it would be rash to deny.

Indeed, we are informed by the science of *Comparative Psychology*,[1] that the pulse of a rabbit beats four times as rapidly as that of a bull, and consequently the rabbit will, in the same interval of time, perceive four times as quickly, and will be able to execute four times as many acts of will, and hence will experience four times as much as the bull. In the same astronomical length of time, the inner life and perceptual world, in the case of various animals, including man, will take place at different specific rates, and it is on these rates that each of these living creatures bases its subjective measure of time.

From the foregoing we can perhaps obtain some idea of how utterly our perceptions of nature depends upon the particular form of our limited conception of time and space.

Our Conception of Space

Our conception of space is three dimensional, that is to say, for us space is apparently extended in three directions. For instance, the north-south direction, the east-west direction, and the up-down direction. The nature of our mind makes it necessary for us to locate any place or *point* in space by its relation to some other point, by its three directions from the other point we are measuring from.

Einstein, however, conceives of the universe as having four dimensions instead of three. One of these dimensions may be *time*. For him apparently, as with many other philosophers, space and time are merely forms of thought, the framework of ideas,[2]

[1] *Principles of Psychology* (larger edition).

[2] See Kant's teaching about space and time which is contained in two portions of the *Kritik of Pure Reason*: in Pt. I, the *Æsthetic*, and in the first and second *Antinomies* of Pt. III, the *Dialectic*. See also, Henri Bergson's *Creative Evolution*, pp. 21-23 and p. 203.

and if so, is it not legitimate for us to reconstruct these ideas so that they answer the requirements of our new conceptions? As a matter of fact we do this very thing. With the aid of Euclid and his successors we have constructed a geometry of three dimensions that answers perfectly for all ordinary requirements, such as laying out a town lot or measuring the height of a building. It is customary for us to speak of "*flat-ground*" and "*water-level*" without any regard for the fact that all our *straight* lines on the earth's surface really form curves that return to us after being extended 25,000 miles or less. Only when we measure mile lengths do we commence making corrections for the curvature of the earth in the third dimension.

If then, as seems probable, we shall be obliged to make allowance for the curvature of the universe in a fourth dimension when making certain astronomical measurements, it will simply mean a little more mathematical calculation for our astronomers, and it may be the means of relieving their minds of some of their present perplexities. While some people seem bent upon throwing a veil of mystery over the idea of a fourth dimension, for the mathematician, there is nothing very mystical or mysterious about it, any more than there is about the other three. For the mathematician, if a fourth dimension exists at all, it is simply a measurable direction, and he can use five dimensions or n dimensions if he finds it necessary to do so.

It is sometimes objected that we cannot *see* a figure in four dimensions even "with the mind's eye." It is therefore asserted by some, that the conception is absurd. Such people are described by Maeterlinck[1] as moving in the illusion of seeing and knowing only those things which are strictly indispensable to their little lives, they do not even suspect the narrow extent of their feeble limitations. They lack entirely the faculty of imagination.

That we are unable to visualize a figure in four dimensions is hardly an objection to the possibility of its existence. As a matter of fact, we cannot actually see any figure of more or less than two dimensions; the others we are obliged to take on faith.

It is impossible for us to see the mathematician's point since it has no dimensions, no size, at all. When the school-boy says:

[1] *Our Eternity*, p. 233.

"Let that be the point *A*," what he is really pointing out to us is not really a point at all; it is a comparatively large irregular splotch of white chalk on the black-board.

It is likewise impossible for us to see a mathematical line since it has one dimension only, length and no breadth. But when we set four lines at right angles to one another we have a square, and this is a dimensional figure that we can really see if the enclosed surface is of a different colour from the lines drawn. If we place six squares together at right angles we have a cube. We are, however, unable to see such a figure in its entirety at one time.[1] If we look at a cube from an angle we see something that looks like a square with a couple of lozenges on the sides. This is probably due to the fact that the retina of the human eye is practically a plane surface; and we therefore can see only a two dimensional projection of a solid.[2] As slightly different pictures of an object are presented to us by each of our two eyes, we infer from these the size, shape, and distance of the object. This, however, is essentially guess-work, like our speculation about the other hemisphere of the moon.

It is true that we have a fairly clear idea of a cube in spite of the fact that we have never seen a cube in its entirety. But when we attempt to visualize the hyper-cube, *i.e.*, the four dimensional figure corresponding to the cube, our imagination is strained to the breaking-point.

Some mathematicians claim that by a long and arduous process of thought, they have grasped a sort of shadowy and fleeting perception of it, but we must presume that these mathematicians were endowed with constructive imaginations of high power, and their visions, if not purely imaginary, are of little assistance to the average layman.

While we may be unable to visualize the hyper-cube, we have certain well-defined ideas about it; we have even given it a name. It is known as the *tesseract* and is bounded by eight cubes just as the cube is bounded by six squares and the square by four lines. The tesseract has 24 square faces, 32 edges, and 16 right-angular corners.

(*To be concluded*)

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[1] See Spencer's *First Principles*, Chap. IV, pp. 63-89.

[2] See *Easy Lessons in Einstein*, pp. 27 to 30.

REVIEW OF PUBLICATIONS

Les Progrès Récents de l'Astronomie, par Paul Stroobant, Volume IX, Années 1915-1920, Premiere partie *Le système solaire*, 391 pages.

Professor Stroobant, Assistant Director of the Royal Observatory of Belgium, Professor at the University of Brussels, President of Committee No. 3 and member of the committees Nos. 5, 16 and 20 of the International Astronomical Union, is too well-known in the scientific world to need an elaborate introduction. For several years, beginning in 1905, he has published each year a little book entitled *The Recent Progress of Astronomy*, each volume giving in a clear concise style a practically complete view of all the work done in astronomy during the year for which it was written. During the war, however, it was impossible for Professor Stroobant to write his annual book—very few scientific publications were sent to Brussels—the beautiful buildings of the Observatoire Royal de Belgique were used by the German military machine as a central meteorological office from where it often was decided to send the Zeppelins over London and bombing planes over the Allied lines in France. The buildings were also frequently used as sleeping quarters for German officers and soldiers.

Professor Stroobant, however, has decided to make up for that period of darkness and has proposed to write two books concerning the progress of astronomical science during the years 1915-1920. The first book, which is now published, deals with the Solar System —while the second, which we are awaiting with great impatience, will deal with the Stellar world; it will, no doubt, give us a clear conception of the amazing discoveries that have been made very recently in this field of science.

The Solar System deals first with the sun, where mention is made of the study of the solar rotation at the Dominion Observatory by Dr. J. S. Plaskett, Dr. R. E. DeLury and Mr. H. H. Plaskett, who showed that the velocity of rotation differs at different solar latitudes. It mentions also the work of the Hindu M. N. Saha on the effects of ionization in the solar atmosphere, work which we know has been extended to the stars. The most import-

ant work, however, is that done at Mt. Wilson under Dr. Hale's direction, where mention is made of the discovery of the magnetic bipolarity of sunspot groups and the law that during a solar cycle of approximately eleven years, if the preceding part of a group of spots is magnetically positive in the northern solar hemisphere, the following being negative—it will be the reverse in the southern hemisphere, the preceding part being negative. In the next solar cycle, *i.e.*, during approximately the following eleven years, everything will be reversed, the preceding part of a group being now negative in the northern hemisphere. The relation between the magnetic charges of sunspots and magnetic storms on the earth, accompanied by northern lights, is also emphasized. Of special interest to Canadians is the study by S. B. Nicholson at the Mt. Wilson Observatory of the exceedingly large and active group of spots of March, 1920. They produced the magnificent aurora of March 22nd, of which descriptions have been published in this Journal—one of the most magnificent displays that man ever witnessed. Spots were observed in the region occupied by this group as early as December 26th, 1919; on the 30th they formed a small bipolar group of regular polarity. On January 4th, 1920, the principal spot exhibited a negative magnetic field of 3,200 gausses intensity in the middle of its umbra, but the two little spots that followed had respectively positive fields of 1,000 and 2,500 gausses intensity. The evolution of the group of spots from now on was very interesting and during its fourth revolution around the sun, in March, it showed remarkable currents of sunspots with many bipolar pairs of spots of which the strongest positive and negative magnetic fields had intensities of about 3,000 gausses. Father Cortie in England (M.N., vol. 80, p. 574) discussed the relations observed between this group of spots and terrestrial magnetic phenomena.

The results obtained at several eclipse expeditions are mentioned at length. Among them might be cited the observations of Dr. C. A. Chant at Matheson (Colorado) on June 18th, 1918. The British expedition at Sobral (Province of Ceara, Brazil) will remain in the annals of history as the first favourable one where attempts were made to verify the famous Einstein effect (May 29th, 1919).

Very important results of the observation of the eclipse of

June 18th, 1918, are those of J. Kunz and J. Stebbins on the determination of the brightness of the solar corona by the use of a photo-electric cell. It leads to the possibility of determining the nature of the solar corona without an eclipse, using such a cell. (Obs., vol. 42, p. 136.) Several experiments have been made along these lines by Ellerman at Mt. Wilson.

The problems of planetary motions are then dealt with in extenso, among them the motion of the perihelion of Mercury and of the node of Venus. Cosmic masses near the sun, as predicted by Seeliger, cosmic refraction due to an extensive atmosphere that envelops the sun as treated by Courvoisier, tend to explain some of the anomalies in the motions.

Many other questions, such as those relating to the planetary albedoes, the variation of latitude, the physical aspects of the planets, the small planets, the theories of perturbations, the comets and all the problems originating from observations of objects of the solar system, are treated with an abundance of details. Among the comets the most remarkable was perhaps Mellish's Comet, 1915*a*, whose nucleus separated into several parts. Up to about the beginning of May, 1915, it was single; the 3rd of May, for instance, according to observations made at Johannesburg, the nucleus seemed considerably lengthened, while on the 28th of May it was distinctly double. A photograph taken by H. Thiele with the powerful reflector of the Bergedorf Observatory (Hamburg) shows two secondary nuclei on the 5th of May, while on the 12th Professor Barnard, with the 40-inch refractor of the Yerkes Observatory, saw two nuclei distinctly. Most interesting also were the photographs obtained by C. O. Lampland with the 40-inch reflector of the Lowell Observatory; they showed plainly three nuclei whose mutual distances were increasing appreciably from day to day. It was a remarkable example of disintegration of the head of a comet and perhaps never noticed before in observations.

Besides all the above results mentioned, Professor Stroobant's book contains a rather short but clear account of the work that has been done on the Einstein theory.

In short, the book is among the best to give any one a clear idea of modern astronomical knowledge.

F. Henroteau.

Geodetic Position Evaluation,, by W. M. Tobey, Publication No. 7 of the Geodetic Survey of Canada.

The computation of geodetic latitudes and longitudes constitutes a fundamental problem in geodetic calculations, and many methods have been devised for its solution. The above publication contains an account of the method employed on the Geodetic Survey of Canada.

If the earth were spherical in form the problem would be a simple one of spherical trigonometry; but as its figure is approximately that of an oblate spheroid, and is always assumed to be such in geodetic calculations, a complication is thus introduced into the problem which is overcome in different ways by different investigators.

In nearly all of the methods that have been proposed the solution is given in the form of infinite series, which are more or less convergent, a sufficient number of terms being retained to give the desired degree of approximation. In the method we are considering, however, only a limited use is made of series, but a frequent use is made of tabulated values of the differences between an arc and its tangent and sine, in dealing with the small angular magnitudes to which it is applied.

In this way the numerical work is reduced to a minimum without at the same time sacrificing precision in the results. The method, in fact, meets the requirements of the longest lines that usually occur in a trigonometric survey; and provision is also made to extend the formulæ so as to serve for the lines of extreme length that are sometimes met with in carrying such a survey through a mountainous region.

The method of the Canadian survey thus provides a convenient solution for the ordinary length of line occurring in a geodetic survey, and at the same time is readily applicable to the longest distance between intervisible points that is likely to be found on the earth's surface.

A number of useful tables have also been computed that are necessary in the application of the formulæ, and are appended to the work.

LOUIS B. STEWART.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries

The Occultation of Venus, January 13

During much of January the sky was cloudy, but at the time of the occultation it was clear at Toronto and at many other places in Ontario. An old friend of the present writer, who is serving his country well on a poultry farm, was one of the fortunate observers of the phenomenon and describes his experience thus:

"As I was going out in the morning a little before six, with my hands full of lanterns, one for each pen in the hen houses, placed there to encourage greater activity on the part of the laying staff, which is fed long before daylight, I noticed Venus very close to the moon and right in its path. 'Miss Venus,' I thought, 'you will get run over in a few minutes if I'm not mistaken,' and went on with my chores. When I had fed the hens, the cows and the horse, cleaned the cow stable, groomed the cows preparatory to my sister's milking them, I looked again and Venus appeared like a bright jewel tacked on the bright edge of the moon. 'Jove! but I'd like to see the planet's light snuffed out,' I said, and went to tell my sisters, who were now stirring in the kitchen, about it so they might have a view. When we came out Venus was gone. I had missed the contact.

"When I had watered the hens, taken in the lanterns and cleaned up the hen houses, Venus was still obscured. I ran into the house and said, 'She will emerge in a moment,' and got outside again just in time to see the planet flash from behind the dark side of the moon. Going in for breakfast some time later the sun was well up but both the moon and Venus were clearly visible."

Coincidences

A short time ago the present writer was conducting a computation class at the University of Toronto, the problem then

under consideration being the length of a degree of latitude at Toronto. The result came out 111.11 . . . kilometres. The succession of five 1's was remarked as a peculiar occurrence. It recalled a strange coincidence at the Eclipse Camp at Wallal, in Western Australia, where, in a party of seventeen dining in one of the mess-tents, three of them had the same birthday, namely September 7. One was from Australia, one from the United States and the third from Canada. There were seven students in the class and two of them intimated that their birthdays were also on September 7.

A Crescent Moon Sets in the Morning Again

In the *Christian Register* of April 12, 1922, appeared the following quotation. A journal bearing such a name should publish only the truth, but our readers will have to exercise their own judgment as to its accuracy:

> As I went up one of the grand mountains in the pale moonlight one autumn morning not a sound broke in on the monotone. The crescent moon, now fast setting, hung on a soft shaded sky. I looked again; she had dipped behind a mountain top.

The Times of the Minima of Algol

For some years the times of the minima of Algol given in the Society's *Handbook* have been calculated from Chandler's formula with Hartwig's correction of 1h. 30m. earlier. It appears that a further correction should be made. In the *Astrophysical Journal* for 1921 Stebbins gives an accurate determination of a minimum which is about 1h. 20m. *earlier* than the *Handbook*. Mr. J. A. Pearce writes from the Lick Observatory that from observations made on Tuesday night, September 12, 1922, the minimum was at 23h. 36m. P.S.T., which is 1h. 17m. earlier, agreeing closely with Stebbins. A correction will be made in next year's publication.

Some Cabled Scientific Information

One often wonders where news-gathering companies get their information and also why some of its "stories" are ever sent over cable and telegraph to all the world. On Christmas Day, 1922, there appeared in some of the Canadian papers the following

despatch. It was introduced by prominent headlines: "Star of Bethlehem shines o'er France. Peasants of Normandy Speculate over Bright Light in Heavens. Scientists are Puzzled."

(Associated Press Cable)

Angers, France, Dec. 24.—The peasants in the district who are preparing to celebrate Christmas are mystified by a huge bright light which has appeared in the heavens for the past two days, and are asking, "Is this a new Star of Bethlehem?"

The light has a varying appearance, now like a luminous star, and again like a small crescent of the moon. The official meteorological services are puzzled, and thus far have been unable to explain its prolonged presence, though attributing it to a meteor swarm.

The light was first seen Thursday morning, gleaming feebly 18 degrees above the horizon. On Friday it was higher up and more pronounced, moving at an angular rapidity of one twenty-fifth of one degree. The whole countryside watches for its daily reappearance, and is wondering what special significance attaches to the light.

Undoubtedly the bright object was the planet Venus, and how the "official meteorological service" or any "scientists" could be puzzled is almost beyond conception. Would that it were a new Star of Bethlehem to give France and the rest of Europe peace!

Another despatch which must have caused some astonishment was sent in September, 1921, by "special cable," and read as follows:

Milan, Sept. 20.—In view of the troubled times in Italy the liquefaction of the blood of St. Januarius was eagerly awaited by a crowd of nearly 10,000 people in Naples Cathedral to-day. The belief is held if the blood does not liquefy disaster threatens the city, and the consummation of the miracle after 42 minutes' invocation was hailed by the pealing of all bells in the city and the firing of cannon from the fort.

Usually the liquefaction is said to take a little more than 20 minutes, and only twice or three times has the miracle not been in evidence. On each occasion trouble has come to Naples.

It is generally believed here that d'Annunzio has declared a revolution in Italy to establish a republic, the uprising to begin on September 23. Already a general strike has been declared in Rome and the extremists are prepared in the north for action, if possible, bombs being used against any men who might wish to continue working. But all this, it is believed, will be ineffective in the south because the blood of St. Januarius has been liquefied.

Comment is hardly necessary.

ODE TO THE PLANET MARS

Red star of War! while armies sleep,
To march to slaughter at the dawn,
'Tis mine a faithful watch to keep,
Lest suddenly the foe come on.

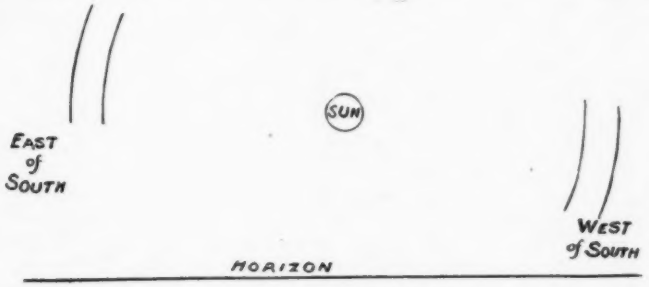
I peer into the gloomy wood,
Alarmed at some portentous sound,
Then gaze on thee, red orb of blood,
Whose beams a warring world confound.

O, from among the stars retire,
Elsewhere send forth thy rays malign,
Thou baleful globe of restless fire,
Man's blood is poured for thee like wine.

—CLINT PARKHURST in *The Palimpsest*, Iowa City.

AN INTERESTING HALO

Mr. A. J. Clark writes from Maple, Ont., on December 20th, as follows: "A most interesting and, to me, a novel phenomenon was observed by us here at Maple, yesterday (December 19th) at about 10 a.m. to 1 o'clock, which I might, rather awkwardly, describe as a 'snow' rainbow. The sky was clear and cloudless at the time, except for a slight, whitish haze toward the south, which, however, was not sufficient to appreciably dim the bright sunshine. The bow was broken as per the accompanying diagram, and for brightness resembled a fading summer bow with alternate strength and weakness in the prismatic range. Air frosty. No wind."



Halo seen at Maple, Ont.

Greetings from Western Australia

The members of the Eclipse Expedition to Wallal, upon their return to Perth were guests of the West Australian Astronomical Society on Saturday afternoon, October 14th, and the leaders of the different parties gave outlines of the observations which had been made, and also bore fraternal greetings to the Society. Mr. C. Nossiter, who is president of the Society, is Chief Assistant in the Perth Observatory and he headed the Western Australian party at the eclipse. He asked the present writer to convey to the members of the Royal Astronomical Society of Canada the cordial greetings of the Australian Society.

Director Campbell now President of the University of California

On the day of his arrival home from Australia Dr. W. W. Campbell was offered the position of President of the University of California, and though he hesitated he felt it his duty to accept. Dr. Campbell was born on April 11th, 1862, in Ohio. He was instructor in Astronomy in the University of Michigan from 1888 to 1891, and in the latter year became astronomer in the Lick Observatory. He was acting director in 1900 and since January, 1901, has been director. During this time he has achieved distinction for himself and added distinction to the Observatory. On the recent eclipse expedition he was the oldest of the members and yet I think I am correct in saying he was the most active of all. He was usually the first one up and he would climb to the top of the forty-foot tower and take part in the heavy labour of the camp with a quickness and vigour which distanced some of the rest of us. His astronomical friends throughout the world will wish that his bodily vigour may continue in the difficult position to which he has been chosen. It may be recalled that E. S. Holden, the first director of the Observatory, also acted for some time as president of the University. Dr. Campbell will still retain the directorship of the Observatory at a nominal salary, but an associate director will be appointed to undertake the administrative duties of the institution.

A letter from Professor Frost states that Professor E. E. Barnard died at the Yerkes Observatory on the evening of February 6. A biographical sketch will appear later. C. A. C.

MEETINGS OF THE SOCIETY

AT TORONTO

December 5, 1922.—The regular fortnightly meeting was held in the Physics Building, at 8 p.m., the President, Mr. W. E. W. Jackson, in the chair.

The Secretary read a communication from the Winnipeg Centre regarding intra-centre lectures, which was referred to the Council for action.

The following persons were nominated for membership: Dr. F. J. Neubauer, Lick Observatory, California; Mr. W. J. Barlow, Milwaukee, Wis.; Mrs. H. H. Giroux, Brooklyn, N.Y.

The assistant librarian reported that 56 periodicals and publications had been received during November.

In regard to the appearance of Mercury in the mornings during its recent westerly elongation on Oct. 30, Prof. Chant said that he saw this planet very well for a period of two or three weeks while in Australia. In reply to an enquiry he described the appearance of the Constellation, the Southern Cross, and mentioned that the appearance of Canopus was much like Sirius.

Mr. A. F. Miller reported that a small sunspot was visible at the present time, and that it was apparently not the same which appeared during the sun's preceding revolution.

The President, Mr. W. E. W. Jackson, reported that in England recently extensive efforts are being made to collect information upon phenomena of static electricity, radio work, and auroral interruptions, in their various manifestations as terrestrial phenomena, and that the chief promoters of the efforts are hopeful of getting some good results.

Rev. Prof. C. V. Pilcher of Wycliffe College gave the address of the evening on "The Stars in Literature", and in the opening parts of his discourse dwelt at some length on references to the stars and astronomical features in the Bible. The Bible being the greatest work in literature, Mr. Pilcher pointed out how strangely the first biblical reference to the heavenly bodies, in which they are said to be "for signs, and for seasons, and for days, and years", had been fulfilled in the service rendered by the phenomena of the skies to archaeology. The Egyptians began their year with the first visible rising of Sothis (Sirius) before the sun. But as they had no leap year, in every four years the nominal calendar gained a day on the real year. Thus the nominal months passed round the whole circuit of the seasonal months in a period of 1460 years. This was called a Sothic cycle. One such cycle was complete in 139 B.C. Hence the state of each cycle's commencement is known. Thus, if we are told that during the

reign of a certain Egyptian monarch Sirius rose at such and such a time in the nominal year, we can at once state the monarch within the Sothic cycle.

An eclipse of the sun was the means of settling the Assyrian chronology. Lists of years each called after some public official (the epoque canicule) had been discovered. If a point could be fixed every date was clear, but without this the whole list was "up in the air". Fortunately it was mentioned that an eclipse of the sun took place at Nineveh in a year called after a certain official. The astronomers dated the eclipse, and Assyrian chronology became luminous.

The speaker pointed out that only the Jews of ancient peoples read the stars aright. To them they were not mysterious objects of astrological speculation, but beacons of hope (Genesis 15, and Josiah 40).

With regard to the "Star" seen by the Magi at the birth of Christ, the lecturer pointed out that in the astrology of Babylon, Saturn was connected with Palestine. The zodiacal constellations of Virgo and Leo also seemed to have a similar connection. Some conjunction of Saturn in Virgo or Leo might be the "Star". The reference to the Star "standing over the house" was obviously the description of a popular observer.

The speaker passed rapidly over some of the greatest poems of European literature, and ended by dwelling on the interesting case of an Icelandic farmer of the nineteenth century, told of in an Icelandic writing, who without education taught himself enough mathematics to calculate eclipses with the utmost accuracy.

At the conclusion of Professor Pilcher's interesting address the President, Mr. Jackson, referred to the inspiration which the stars have had on many peoples and nations. When speaking of the address, Prof. Chant said we need more men like Prof. Pilcher on the staffs of our theological colleges, men who can give reasonable explanations of scientific matters to students. This address recalled the book called "The Astronomy of the Bible" by Maunder, a devout man who made a special study of Hebrew in order to interpret the Bible properly. Tennyson was in striking contrast with the figurative language of the Bible, as he was accustomed to our present language, and not the ancient way of speaking. Mr. John A. Paterson expressed his pleasure at hearing a classical man discuss the problems of astronomy, as we like to get away, sometimes, from angles and mathematical formulae and hear about the literature of the subject. It is a great range from the Babylonians down to Tennyson, who, whenever he wrote a scientific poem, submitted it to a scientific man for suggestions. Dr. Watson spoke of Prof. Pilcher's general principle of interpretation of the Bible expressions as a valuable part of his address. An expression like that where Zion will eat straw as an ox is figurative, and the same principle of interpretation can be applied generally.

The meeting, after an expression of thanks to the lecturer, was adjourned.

AT OTTAWA

March 24, 1922.—Mr. W. E. W. Jackson, M.A., of the Meteorological Office, Toronto, gave the lecture of the evening, on "Terrestrial Magnetism".

Reference was made by Mr. Jackson to the dependence of civilization on the

magnet. He cited as examples, the British Navy, electric lights, trolley systems, communication, etc., and proceeded to give a brief historical review of the growth of our knowledge of magnetism. Some of the properties of the lodestone, or magnet, were known to the Chinese long before the Christian era, for as early as 2000 B.C. they constructed south-pointing charts. They were also apparently aware of the fact that the compass does not always point true to the north. According to the writings of Thales the fundamental properties of the magnet were known to the Greeks as early as 640 B.C. The earliest records of the use of the mariner's compass in Europe are near the end of the twelfth century. Perigrinus in the latter part of the following century improved the existing forms of the compass by introducing the azimuth compass. The "Garlic Myth" was referred to, according to which mariners were warned not to eat garlic or onions, for it was believed that the odour would deprive the magnet of its virtue.

The year 1492 should be considered as the year of the birth of Terrestrial Magnetism. It was Columbus's voyage to the New World that revealed, to Europeans at least, that the compass did not "point true to the pole", but changed its direction from place to place. In order to pacify the terrorized sailors Columbus stated to them that the stars had moved while the magnet remained stationary. About 1510 Hartmann discovered magnetic declination on land. He is credited with the construction of the sun-dial compass. The next notable discovery was that of dip by Robert Norman in 1576. In 1600 Gilbert's "De Magnete" was published, and was a complete summary of properties of magnetic bodies up to that date. Gilbert concluded that the earth was itself a great magnet having its poles coincident with the poles of the earth. Gauss two centuries later made a remarkable contribution to our knowledge of this science. Among other things he developed a method of measuring absolutely the horizontal force of the earth's magnetism. In 1839 the British Government established the Observatory at Toronto and first used there one of the instruments designed by Gauss and constructed by Jones. This instrument was exhibited to the audience at the conclusion of the meeting. The Observatory was in operation at Toronto from 1839 to 1898, when, on account of the disturbing influences due to the trolley system, it moved to Agincourt where continuous records have since been taken. The photographic method of obtaining the changes in the earth's magnetism, which was introduced about 1880, was explained. Diagrams illustrating the complex character of the secular change of the magnetic elements were shown. The relation between sun spots, aurora and magnetic disturbances was touched upon; there was evidence that these three phenomena are inter-related.

The lecture was well attended; the President, Dr. R. E. DeLury, occupied the chair.

April 7, 1922.—Dr. F. J. Alcock of the Geological Survey of Canada gave the lecture of the evening on Volcanism. Dr. R. E. DeLury presided.

Dr. Alcock in his introductory remarks gave a short outline of early theories held regarding volcanic activity. The igneous or deep seated rocks are the most

important. It is in these rocks that ore deposits are found. These ore deposits are from deep seated intrusions and in the process of the activity of the volcanic disturbance, the ores are concentrated in the solidifying into veins. This explains why gold and silver are often found in veins many hundreds of feet below the surface. The New Ontario and Lake Superior regions are good examples of such activity. The ore deposits of these fields give proof that Canada at one time had active volcanoes, and that the rocks of these regions are of volcanic origin.

Dr. Alcock outlined various kinds of volcanic activity. The submarine volcano of Iceland, where a fissure 20 miles long was opened up and poured forth lava which covered 220 square miles; volcanoes of this kind were spoken of as the quiet type. During tertiary times, the great wheat lands of the United States and Canada were liquid lava, an area of 200,000 square miles. It is supposed that these volcanoes were in action 200 million years ago. The activities of volcanoes in India in tertiary times put forth enough material to cover Canada to a depth of 300 feet. Between successive lava flows great periods of time elapsed.

The greatest single explosion recorded occurred on the small island of Krakatoa in the Straits of Sunda in 1883, when the whole top of the island was blown off, and left water over 1,000 feet in depth. The report was heard 1,000 miles.

Theory of Volcanic Activity: The surface of the earth is under stress all the time, due to two movements, rising and falling, which tends to cause strain. The earth's surface has rigidity of glass while the earth as a whole has rigidity of steel, the interior of the earth molten, density of earth 5.5, while interior is greater than 5.5, the interior made up of metallic alloys. The earth is hot inside. This is known from deep mines, a rise of 1° C. for every 100 feet, hence interior would appear as very hot, or that surface layer is sufficient to offset this and behave as a solid rigid body. The earth may act as a solid body, with a molten interior, and as the interior shrinks the outer shell accommodating itself would produce a fissure and we would have the magma flowing out. Reservoirs from which this flow takes place are 5 to 20 miles below the surface.

The active volcanoes in the Hawaiian Islands were spoken of, Mauna Loa in particular. Dr. Alcock illustrated his lecture by many beautifully coloured lantern slides and particularly of Mauna Loa. The slides were much appreciated by the audience.

November 22, 1922.—The second lecture of the Fall term was held on November 22, at Victoria Memorial Museum. Mr. R. M. Stewart occupied the chair. Following the election of Dr. R. Milton Armstrong of Ottawa, the speaker of the evening, Dr. Harlow Shapley, Director of Harvard College Observatory, was introduced by the chairman, and gave his lecture on Star Clusters.

Dr. Shapley in his introductory remarks paid a very high tribute to Canada for the work it is doing in the science of astronomy. He said the government of no other country was so effectively and so successfully carrying on the work of

astronomy as that of Canada, and this is very important, as astronomy can co-operate with other sciences.

Describing the vast system of stars of which the solar system is a part, he said it was flat, or bun-shaped, illustrating it by two aluminum pie-pans placed together, and when we see the Milky Way we are looking out on its edge through thick clusters of myriads of stars. Dr. Shapley discussed in a lucid manner the different methods of measuring the distances of the stars from the earth. His statement of some of the inconceivable reaches of the heavens was staggering in its significance. He explained that the old methods of finding out the distances of the nearest stars had completely failed to discover the distances of the millions of stars that were farther away, and that the scientists had found out a method of telling how far away they were by a study of a spectrum of the light that came from the stars. The intensities of the spectrum lines were measured, and in this way the candle-power or absolute magnitude was determined. It was then a simple matter to obtain distances when the candle-power was known. By the use of such a method (spectroscopic) it had been found out that the light from the cluster known as the Great Hercules Cluster takes 35,000 years to reach this earth, that is, the light that leaves it to-night will be seen here 35,000 years from now. A photograph of this cluster was shown and Dr. Shapley explained that the photographic picture was the result of an eleven-hour exposure with the 60-in. telescope at the Mount Wilson Observatory. This was one of the marvels of photography, that a photograph could be taken in eleven hours of what had taken 35,000 years to reach the earth.

The lecturer outlined the question of the formation of the solar system very fully and told how the older theories as to the work of creation had been discarded, first the ego-centric, then the geo-centric and then the heliocentric theory. In this sandwich-shaped universe are to be seen the finger-prints of creation. Dr. Shapley then outlined how the stars come into existence. First they appear as vast giants formed out of the great chaos of nebulae with a very low density, then, due to gravitation, the large mass gradually contracts, which increases the density and temperature, and finally we have first the red stars, then yellow, white and blue; at this point equilibrium is reached and a reverse process sets in, and the stars follow a shrinking career with a fall in temperature and cool off to their fixed state.

Dr. Shapley's astronomical photographs were the finest ever seen here. The star clusters and different nebulae photographed at the Arequipa station of the Harvard Observatory were truly wonderful. The photographs of the planet Mars were very instructive and from the remarks of the lecturer the idea was given that organisms of some sort can live there, perhaps not nearly so advanced as man in development.

In closing his most interesting lecture Dr. Shapley spoke with convincing earnestness and awe of the enormous dimensions of the universe, the way in which the science of astronomy could collaborate with other sciences in proving the verities of truth, and of the beauty of the whole study and its bearing on philosophy. The study of astronomy inspires humility and reverence in those who follow it.

The auditorium of the Museum was filled to capacity; nearly 300 attended.

At the close of the lecture the chairman conveyed to Dr. Shapley the hearty thanks of the Society for his very able and interesting lecture on such a difficult subject.

November 15.—On the evening of Wednesday, November 15, 1922, a lecture entitled, "From Infancy to Maturity with Astronomy", was delivered before the Ottawa Centre by Ernest A. Hodgson, M.A., of the staff of the Dominion Observatory.

The lecturer traced the developments in astronomy from earliest times, using as a connecting thread the idea of a parallel between the developments in astronomy and the development of a child to manhood.

The remarks on the childhood and youth of the science as reflected in the period preceding Copernicus received the greater part of the attention of the speaker, who outlined the history of astronomy through the times of the ancient Egyptians and Chinese, the period covered by Biblical references, Thales, Anaximander, Pythagoras, Meton, Aristotle, Ptolemy, Hipparchus, Alphonso of Castile, and Copernicus.

The lecture closed with a rapid enumeration of the growth in the science since the time of Copernicus and a brief glimpse into the possible future discoveries and developments in its history.

In the absence of the President, the Secretary occupied the chair, and expressed the thanks of the Society to Mr. Hodgson for his very interesting lecture.

R. J. McDiarmid, *Secretary*.

AT MONTREAL

December 14, 1922.—The meeting was held in the Physics Building of McGill University. The President, H. E. S. Asbury, occupied the chair. Attendance about 100.

The President read a letter from the Secretary-Treasurer, W. T. B. Crombie, who very regretfully stated, that illness renders him incapable of fulfilling his present duties, and firmly requested the Society to elect a successor to his office.

Mr. Justice Howard moved with regret the acceptance of Mr. Crombie's resignation, desiring at the same time that we place on record our appreciation of the services of the retiring Sec.-Treasurer. Mr. Crombie was one of the founders of the Montreal Centre of the Society and it is in no small measure due to his untiring interest that this Centre owes its present success. We sincerely hope that in the near future Mr. Crombie may return to the Executive.

The election of officers for 1923 then followed, with results as below: Hon. Pres., Mgr. C. P. Choquette, Lic.Sc.; President, Mr. Justice E. E. Howard; First Vice-Pres., A. S. Eve, D.Sc., C.B.E., F.R.S.; Second Vice-Pres., H. E. S. Asbury; Sec.-Treas., A. W. Strong; Recorder, L. Sessenwein.

Council: Prof. L. V. King, F. R. Robert, Prof. Gillson, Miss M. Ellicot, John Corway, George Sample, Prof. James Weir.

Following the election of officers, two films entitled, "Worlds in the Making", and the "Mysteries of Space", were shown. These depicted the supposed evolution of the solar system from a spiral nebula; the planets Mars and Saturn rotating with their satellites revolving around them, etc.

The first speaker of the evening, Prof. Gillson, opened his discussion by referring to the various systems in the Universe, which included the solar system, globular clusters, nebulae and multiple stars. These were all illustrated by slides. Spiral nebulae form a large group, of which there are over half a million on record. As far as we know there is only one solar system. All the stars seen in the telescope can be given the form of a large bun; they are all in motion and have an average velocity of 20 km a second. The problem to be faced, as stated by the lecturer, consisted in proposing a theory as to how the solar system, the nebulae, double stars, etc., can be worked out of one uniform law.

Prof. Bancroft, the second speaker, continued the discussion, basing his argument from a geological viewpoint. In geology, we go back to the formations of various ages. Fossils indicate the different stages and recede to the great Pre-Cambrian age when there are no fossils at all. The oldest sedimentary rocks are resting on rocks younger than themselves, and there is no trace of a primordial crust as great masses of molten material from within have obliterated it. Thus in geology there is no trace of a beginning and we must turn to astronomy for a solution. Prof. Bancroft then took up the Chamberlin-Moulton planetesimal hypothesis which attempts to discover the process of earth evolution from a spiral nebula. The conception is this: let us start with a tremendous non-rotating spherical body of gaseous character. Some solid body approaches this mass and in doing so develops tides on it which gradually become greater and greater as it approaches; until finally great explosive belches are thrown out. Then as this solid body rushes past a couple is set up, this matter is turned and the mass swings around as a spiral nebula. The hypothesis comes under two headings: first, the development of a spiral nebula as above, and, second, the gradual accumulation of material into nuclei. This drawing in of diffused matter led to the formation of satellites. Various stresses were then set up. Gravitational, for instance, which tended to squeeze out molten material from the centre. This lighter material was forced to the exterior and thus gases added to our atmosphere. The oceans were squeezed out in like manner.

This hypothesis accounts for some phenomena but not for others: so that in the end we are forced to an expression of frank agnosticism as to the formation of the earth.

Prof. Gillson, resuming his discussion, stated that according to the mathematical calculations of J. H. Jeans, the chances of the above happening were very very small, as only under exceptional conditions could the filament be pulled out sufficiently by the approaching body. Yet, there is no other theory that will account for it. Prof. Gray, in a few well chosen words, commented on the ex-

cellence of the discussions and would carry us still further back in evolution by inquiring as to the origin of the mass of gas out of which the solar system came.

A vote of thanks was proposed by Mr. Browning to the Pathescope Co. for kindly allowing the Society the use of their films.

The meeting concluded with the National Anthem.

AT WINNIPEG

November 8.—The Society met on this date in the usual place, Prof. L. A. H. Warren occupying the chair.

Mr. Walter Jordan was elected to membership

On motion of the meeting the chairman appointed a committee consisting of Mr. Allan (convener), Prof. MacLean and Dr. Miller, to consider the question of purchasing a telescope by the Society.

On motion the chairman also named a committee consisting of Mr. Bastin (convener), Prof. Wilson, Prof. Warren and Dr. Miller to make nominations for the offices to be filled at the annual meeting.

Rev. T. W. Morton, B.Sc., of St. Mary's Cathedral, addressed the Society on "Shooting Stars". Until about a century ago, he said, shooting stars were regarded by astronomers as inflammable vapours accidentally kindled in our atmosphere. It needed one of those amazing spectacles, at which man assists, no longer in abject terror, but with keen curiosity, to bring forth clear and new knowledge. On the night of November 12, 1833, a tempest of falling stars broke upon the earth. North America bore the brunt of its pelting. From the Gulf of Mexico to Halifax, until day-light with some difficulty put an end to the display, the sky was scored in every direction with shining tracks and illuminated with majestic fireballs. At Boston, the frequency was estimated to be about half that of flakes of snow in a snowstorm. Olmstead of Yale observed that they all seemed to radiate from a point in the Sickle of the Lion, and suggested that the apparent divergence was an effect of perspective on meteors entering the atmosphere in parallel lines in some cosmical orbit. From that time, the study of shooting stars became an integral part of astronomy.

It is estimated that 20 million meteors enter our atmosphere on an average in twenty-four hours, and if we count those below the 7th magnitude visible only in telescopes, that number must be multiplied by 20. The vast majority of these are no bigger than a grain of sand. Some are large, and even survive the passage through our atmosphere and reach the earth's surface as meteorites. These meteors travel in space with the planetary velocity of 26 miles per second. The earth has its own orbital velocity of 18½ miles per second; so meteors like the Leonids which meet the earth, rush through the air at the rate of 44 miles per sec., those, like the Andromedids, which overtake the earth, move in the air 8 to 10 miles per sec.

Shooting stars have been sorted out into groups, and more than 5,000 radiants have now been established; the best known showers are the Leonids (Nov. 14-16), the Perseids (Aug. 9-11), the Andromedids (Nov. 27, 28), and the Lyrids (April 19-22).

Investigation of the close correspondence of the orbits of the Leonids and Temple's Comet, and also of those of the Andromedids and Biela's Comet, has led to the conclusion that the disintegrated comets furnish the material for the meteoric showers. By parallax of distant observers, it is found that shooting stars generally become luminous at 80 miles above the earth's surface, and cease to be visible at 40 miles high, their speed having been slowed down by the friction which tore off their outer surface and rendered it brightly incandescent. Daylight, moonlight, clouds, and local range of vision limit the number of shooting stars to be seen by an observer outside the period of showers to about 12 per hour.

Historical records of stones falling from heaven, and hence regarded as sacred, were generally disbelieved until the study of meteorites was taken up. The large museums of the world contain many specimens. They form two classes: (*a*) Siderites—which contain 95 per cent. of iron alloyed with nickel, and (*b*) Aerolites—which contain stony matter with metals. About a third of the earth's elements are found in these visitors from space, but no new element. Certain compounds are present which are not native on the earth's surface. Small black diamonds have been discovered in meteorites in the Canyon Diablo, and as Moissan was able to produce similar diamonds artificially by dissolving carbon in iron at great temperature and pressure and suddenly cooling, so it is conjectured that these meteorites were shot out of our sun or some other star.

We have to thank our atmosphere for protection from the bombardment of meteors. Coon Butte in Arizona is an example of what can happen from meteoric impact. If we had no air, the surface of the earth might be cratered like that of the moon.

November 22, 1922.—The Society met in the usual place, the President, Mr Allan, occupying the chair.

The Committee on Telescopes gave a preliminary report through the Secretary.

Prof. V. W. Jackson, B.A., of the Manitoba Agricultural College, was elected to membership.

The President called on Prof. Jackson for his lecture on New Zealand. Prof. Jackson exhibited a large and excellent assortment of slides, many of them coloured. The climatic range of New Zealand is equal to that of the United States, the two islands extending a long way in a north and south direction. Much rain and no mud are among the many unusual things of the country, the soil of which is a volcanic ash, which does not form mud. Dairying and sheep raising are the big industries, and skylarks and sheep-killing parrots are their pests. Pictures were shown of the marvellous terraces which were obliterated some years ago by a volcanic upheaval. These terraces were formed by the hot silicious water from geysers, and were really a series of pools like natural bath tubs, the water flowing from the rim of one pool over to the next lower one.

Prof. Jackson's account of the country, where he lived for four years, was most entertaining and instructive. After remarks of appreciation of the lecture, the meeting adjourned.

C. D. MILLER, *Secretary*.

AT VICTORIA

October 26, 1922.—The President, W. E. Harper, M.A., occupied the chair. For the benefit of those new in the audience the President explained the benefits to be derived from membership in the Society. He also described the positions of the planets and the constellation of Pegasus.

The lecturer of the evening was Dr. J. S. Plaskett, who spoke on "The Personality and Work of Astronomers of To-day".

The lecturer began by stating that the astronomers he had met were, in general, of charming personality and that the association between astronomers was very friendly and intimate. This is natural when the limited numbers engaged in the science and the character of the subjects studied are considered. The general characteristics of the work of astronomers was then considered from the point of view of national differences and the work of American, English, German and other foreign astronomers compared. The general character of American astronomical work is the emphasis given to the observational side, the completeness of equipment and the great advances in the astrophysical aspect of the science. American astronomy is however, in general, not very strong theoretically and mathematically. Although English astronomers are also excellent observers their equipment is not, in general, so complete and modern and the trend is rather to discuss, very thoroughly, the observations they do obtain. The treatment of the theoretical and mathematical viewpoints of astronomy by the present English School is unequalled in the world. The work of the German astronomers is characterized particularly by the fullness of the treatment of detail, often carried to too great an extreme. They have not the perfected equipment of American nor the theoretical attainments of English astronomy. The lecturer then spoke of individual astronomers in turn, giving personal reminiscences of all of the most prominent American and English and of many foreign astronomers. He paid strong tributes to the ability and personality of most of these men and illustrated his remarks by about 50 slides made from negatives personally obtained at several meetings of the American Astronomical Society and two meetings, at Mount Wilson and Bonn, of the International Solar Union. He paid especial tribute to the late Dr. W. F. King, Chief Astronomer of Canada, to whom the development of Astronomy in Canada, as a Government activity, is due, and to Mr. A. W. McCurdy for his assistance in the inception of the Observatory in Victoria.

AUGUSTIN SYMONDS, *Acting-Secretary.*

November 21.—The President, W. E. Harper, in the chair. The minutes of the last regular meeting were read and adopted. The following new members were duly elected: Dr. O. S. Parrell, Resthaven, Sydney, B.C.; Rev. W. Lashley Hall, 2023 Belmont Ave., Victoria.

The President announced that there were two questions on the agenda: (1) as to the tides, which would be answered at the next regular meeting, and (2) the meaning of radial velocity curves, which the speaker proceeded to answer. By the radial velocity of a star, we simply mean the speed of the star to or from the

observer. It is only about one star in three that has a changing radial velocity and this gives rise to our velocity curve, which the speaker illustrated by graphs on the blackboard. Slides were shown giving the way in which the radial velocity was determined by means of the spectroscope.

A discussion followed and several questions on the subject were answered by the President.

The President then announced the lecturer of the evening, Mr. Napier Denison, who gave a most interesting account of the exploration of the upper air by pilot balloons.

These rubber balloons are about 18 inches in diameter, and contain the right amount of hydrogen gas to rise, when released, at the rate of 500 feet per minute. Its height is obtained by noting the number of minutes it is observed through a special theodolite, and its angular position determined from azimuth and declination readings each minute. From these readings in conjunction with a special plotting board, the hourly wind velocity and direction for every 500 feet is obtained for these ascents. Through Sir Frederick Stupart, Director of the Dominion Meteorological Service, these balloon ascents were started here in September, 1921, and from then to November 21st, 1922, a period of 426 days, 140 ascents were observed, which was an average of one every third day.

Of these ascents

31	reached	from	5,000 to 10,000 feet
56	"	"	10,000 to 20,000 feet
30	"	"	20,000 to 30,000 feet
10	"	"	30 000 to 40,000 feet
2	"	"	40,000 to 50,000 feet

The maximum height of 46,000 feet was obtained on November 10th, 1922, when the wind velocity at that elevation was 107 miles per hour, and the horizontal distance travelled was 26 miles. That these small objects could be seen at such distances, speaks well for the fine quality of the lenses, the remarkable clearness of the air and the personal interest and ability of the observers, Messrs. Langton and Layton.

The information derived from these balloon ascents is proving of practical value in connection with the weather forecasting on this coast, for in some instances abnormal air wind velocities have indicated the approach of marked weather changes which occurred later on the surface.

Types of weather charts were projected on the screen showing atmospheric conditions on the Pacific Slope before and after certain descents were made. The accumulated data from these ascents will in a few years supply information to plot normal curves of the wind velocities and directions which will prove of practical value to aviators here and also in weather forecasting.

The lecture was followed by a brief discussion and then a vote of thanks was given the lecturer.

R. K. YOUNG, *Secretary.*

December 15.—Annual Meeting held, the President, Mr. W. E. Harper, in the chair.

The following new members were duly elected to the Society: Mr. G. W. Christie, 1032 Fairfield Rd.; Mr. H. H. Smith, 2227 Oak Bay Avenue; Mr. P. H. Elliott, 912 Linden Avenue; Mr. E. G. Haughton, 1932 Cowan Avenue.

Six nominations for membership were made.

The President then called upon Dr. R. K. Young, who gave an account of the expedition to observe the total eclipse of the sun visible in Australia September 21st, 1922.

The lecturer explained with the help of a slide the cause of an eclipse and its variable character. In the one under discussion the shadow was 120 miles in diameter; striking the earth on East coast of Africa it travelled S.E. across the Indian ocean and thence across Australia. Continuing, Dr. Young stated that it is only at a total eclipse that the light of the sun is cut off from adjacent regions of the sky, thereby making it possible to photograph the same. Astronomers were more than ever desirous to have accurate photographs of the stars in the neighbourhood of the sun on account of the confirmation or otherwise that would thereby be afforded of Einstein's "Theory of Relativity".

For some 300 years the classical mechanics of Newton had been able to explain astronomical phenomena. Due, however, to greater precision of measurement anomalies had been found—accurate experiments of the velocity of light failed to detect the motion of the earth relative to the ether. Dr. Young explained the difference of the Newtonian and the Einstein conception; in the former space, time and matter are independent entities, in the latter they are connected by certain relationships.

The theory has been able to explain the observed discrepancies in the motion of Mercury's perihelion. It also predicts the shifting of the spectrum lines towards the red, and also that the stars, apparently near the sun, will be displaced outwards. It was with the object of testing this latter prediction that Dr. C. A. Chant organized the expedition to Australia.

The lecturer described the camera Dr. Chant designed to take the photographs of the stars.

The possible stations for observing the eclipse were next dealt with. Wallal, a point on the N.W. coast of Australia, was decided upon. Leaving Victoria on June 16th, the astronomers arrived at their destination on August 29th. Slides were shown illustrating the difficulty of transporting the equipment through 2 miles of surf. Further slides showed the work done in the next three weeks and the details of plate exposure were given. Dr. Young laid stress on the anxiety experienced up to thirty seconds before totality as the light did not permit the star to be seen on the cross wires of the instrument.

Two good plates were secured and a number of others bearing on the light emitted by the corona.

A hearty vote of thanks was passed.

Members of the Society remained after the lecture to elect officers for the coming year.

The Secretary's report for the past year was read—on motion Mr. Drewry, seconded by Mr. Christopher, was adopted.

The Treasurer then read the financial statement. Owing to a slight discordance in some of the items in the bank account which indicated that the bank had made some slip in the balance, the auditor was unable to completely audit the books, and their final adoption was left over until the next meeting.

The President then vacated the chair, this being taken by Mr. Drewry: the election of officers was proceeded with.

Dr. Plaskett, in moving that Mr. Harper be asked to continue as President for another year, paid special tribute to the way in which he had conducted the Society during the past year. The motion was seconded by Mr. Hibben.

Mr. Harper, in replying said he had hoped to step down and out this year, but the meeting unanimously asked him to continue.

The new officers are as follows: Hon. President, Dr. J. S. Plaskett; President, W. E. Harper, M.A.; Secretary, F. Moore; Treasurer, J. P. Hibben; Councillors: G. W. Christie, H. H. Smith, Mrs. Christopher, J. Duff, H. H. Christie, John Dean.

Mr. H. H. Plaskett was elected auditor.

Votes of thanks were tendered to the city papers and the School Board.

F. MOORE, *Secretary*.

The Royal Astronomical Society of Canada

OFFICERS FOR 1922 (Revised to March 1st, 1922).

Honorary President—Hon. R. H. Grant, Minister of Education for Ontario.

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